NASA Contractor Report 4374

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FOREWORD

The work described in this report was performed under Task 11, "Functional Decomposition of the Commercial Flight Domain for Function Allocation" of Contract NAS1-18028, Advanced Transport Aircraft Operating Systems Development Studies (ATOPS).

James C. McGuire has been the Principal Investigator for Douglas Aircraft Company (DAC) from May 1990 to the present. Richard T. Goins was DAC's Principal Investigator during the period March through April 1990. William A. Miles made significant contributions to the early phases of the project, acting as Team Leader.

William J. Cody has been the Principal Investigator for Search Technology, Inc. since May 1990, providing support to DAC as a subcontractor.

NASA's Technical Monitor for this contract is Kathy H. Abbott, Langley Research Center.

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ILLUSTRATIONS

TABLES

ACRONYMS AND ABBREVIATIONS

A/C	Aircraft
ADF	Automatic Direction Finder
ADJ	Adjust
AFSCM	Air Force Systems Command
AGL	Above Ground Level
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
CAD	Computer Aided Design
CADSS	Cockpit Automation Design Support System
CAE	Computer-Aided Engineering
CALS	Computer Aided Logistic Support
CAPT	Captain
CAT	Cockpit Automation Technology
COMF	Comfortable
COMM/NAV	Communication/Navigation
CONTINU	Continuous
CONTL	Control

DAC	Douglas Aircraft Company
DEP	Depart
DEPRTR	Departure
DME	Distance Measuring Equipment
DoD	Department of Defense
DOS	Disk Operating System
ECP	Engineering Change Proposal
ETA	Estimated Time of Arrival
FAA	Federal Aviation Agency
FFBD	Functional Flow Block Diagram
FO	First Officer
FREQ	Frequency
FWD	Forward
GND	Ground
HF	High Frequency (radio)
HLDG	Holding
HZ	Frequency in Hertz (cycled per second)
ICAM	Integrated Computer-Aided Manufacturing
ID	Identification
IDEF0	Integrated Computer-Aided Manufacturing Definition Method, Version .... Zero.
ILS	Instrument Landing System

INFORM	Information
INS	Inertial Navigation System
INTERMIT	Intermittent
IRS	Inertial Reference System
JFK	John F. Kennedy International Airport, New York
LA	Los Angeles
LAX	Los Angeles International Airport
MSL	Mean Sea Level
OBS	Observe
PC	Personal Computer
PERT	Program Review and Analysis Technique
POSN	Position
PTT	Push To Talk
R	Right
RAS	Requirements Allocation Sheet
REC	Receive
RET	Retraction
RFP	Request For Proposal
RMS	Root Mean Square
RNWY	Runway
RW	Runway

SADT	Structured Analysis and Design Technique
SAINT	Systems Analysis of Integrated Networks of Tasks
SID	Standard Instrument Departure
TACAN	Tactical Air Navigation
TOC	Top of Climb
TOCG	Take Off Center Of Gravity
TOD	Top of Descent
TOGW	Take Off Gross Weight
TTL	Task Time Line
UHF	Ultra High Frequency (radio)
USAF	United States Air Force
VHF	Very High Frequency (radio)
VOL	Volume
VORTAC	Very High Frequency Omnirange Tactical Air Navigation
WPT	Waypoint
ZFW	Zero Fuel Weight
ZFWCG	Zero Fuel Weight Center Of Gravity

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James C. McGuire, John A. Zich, Richard T. Goins, Jeffery B. Erickson, John P. Dwyer, William J. Cody,* and William B. Rouse*

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SUMMARY

Two approaches to function analysis and to function allocation were investigated. One function analysis approach ("Bottom-Up") extracted functions from a very detailed task time line (TTL) database. These were the functions that might have been implemented to produce the task performance documented in the TTL. A second approach ("Top-Down") created a functional architecture of the objective "Accomplish Commercial Transport Missions" using the function modeling method "Structured Analysis and Design Technique (SADT). Comparable functions were found for both methods in the "Lift-Off" segment, at the lowest level of decomposition. In the "Bottom-Up" approach, although the analysts attempted to eliminate references to any specific design implementation, its content might be influenced by the existing allocations. The "Top-Down" model made no assumptions about automation. The "Bottom-Up" approach was valuable in relating functions to the time interval of the mission during which they occurred. It also provided the capability for relating the "Top-Down" model (which does not address time or sequence) to the mission time line. Both methods are valuable. A detailed treatment of each model is given in the Appendices.

The first approach to function allocation, Method A, is a comprehensive, iterative process that is integrated with the system engineering effort. It emphasizes the iteration of the three steps of allocation, design and evaluation. This method explicitly incorporates a "human-centered" approach to allocation, viewing the human operator as a multidimensional resource whose cognitive and performance characteristics must directly influence the allocation process. This method also encourages the development of adaptive allocation schemes capable of making on-line decisions responsive to situation-specific changes on the flight deck. The second approach, Method B, is a relatively brief, simplified system designed to provide an effective first cut allocation. Method B comprises two components: A set of decision criteria diagnostic of a function's most appropriate allocation, and a rule system that acts on inputs from the decision criteria to yield initial allocations. This rule system is designed to capitalize on the relative importance and context-sensitivity of the decision criteria in its determinations of effective allocations. In this respect, Method B affords the designer a useful allocation scheme and a practical, straightforward approach to defining an initial allocation that permits the designer to proceed to more detailed and definitive evaluations.

Shortcomings apparent in available methods for function analysis and function allocation are discussed, including the need for validation in the operational environment. NASA's recent contribution to the solution of this last problem is noted.

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INTRODUCTION

THE ROLE OF AUTOMATION IN AIR TRANSPORT OPERATIONS

In recent years, the rapid growth in commercial air travel has imposed new and challenging demands on the resources of the National Airspace System. This trend will likely accelerate as the expansion of the air transport industry imposes requirements for ever-increasing capacity and operating efficiency. Government and industry have responded to this challenge, in part, by utilizing advanced technology and system automation to enhance performance and cost-effectiveness while maintaining high standards of operational safety. The application of these technologies has resulted in significant changes to air transport operations and the role of the human operator in airborne and ground-based elements of the National Airspace System.

The impact of advanced technology on the role of the flight crew has been particularly important. Extensive uses of electronic display media, digital control devices and automation of on-board systems have unburdened the crew from many tasks that previously required pilot monitoring and/or direct manual control. The corresponding reduction in overall crew workload enables many modern transport aircraft to function effectively in today's operating environment with fewer crew members.

Experience to date with advanced cockpit technology, suggests that judicious use of automation, combined with careful human engineering of the crew interface, offers the potential for substantial improvements in both safety and efficiency of flight operations. A recent survey of airline pilots makes it evident that this potential has not yet been fully realized (ref. 1). Some of the concerns raised by the operational community regarding cockpit automation include the following:

- Increased pilot head-down time associated with programming and data entry for on-board computers
- Increased crew workload resulting from flight plan changes or unanticipated ATC directives in the terminal area
- Loss of pilot proficiency and difficulty in transitioning to degraded modes of operation due to infrequent practice of manual skills and procedures
- Pilot complacency and less rigorous adherence to procedures resulting from over reliance on automation
- Lack of overall "situation awareness" associated with reduced pilot involvement in the conduct of the flight

In attempting to isolate the source of these in-service problems, a variety of possible causal factors must be investigated. These include: (1) the basic division of responsibility between man and machine; (2) the design of displays, controls and operating logic of the man-machine interface; and (3) the training of pilots in the proper use of the technology. It seems likely that the full benefit of cockpit automation can only be attained through a

comprehensive program of research and development, dealing in a balanced fashion with all of these relevant factors.

THE NASA AVIATION SAFETY AUTOMATION PROGRAM

In recognition of these important issues, the National Aeronautics and Space Administration has undertaken a major research initiative known as the Aviation Safety Automation Program. This program was formally initiated in November 1988 with the publication by the NASA Office of Aeronautics and Space Technology of a detailed plan for the research initiative (ref. 2). The primary goal of this program is "to improve the safety of the National Airspace System through development and integration of automation technologies for aircraft crew and air traffic controllers." The technical focus of the effort is embodied in three major program elements. The central objective of each program element may be summarized as follows:

- Human-Automation Interaction—To develop the basis, consisting of philosophies and guidelines, for applying human-centered automation to the flight deck and ATC controller station.

- Intelligent Error-Tolerant Systems—To provide human-centered automation concepts and methods to the flight crew which ensure full situation awareness.

- ATC Automation and Aircraft-ATC Integration—To provide human-centered automation concepts and methods for ATC controllers which allow integration and management of information and air-ground communications.

Work is currently in progress on a number of specific research projects that support these overall goals. NASA Langley and NASA Ames Research Centers share technical leadership of the initiative with active participation of the aircraft industry and academia. The research described in this report was conducted by McDonnell Douglas under the sponsorship of the Intelligent Cockpit Aids Group of the Flight Management Division, NASA Langley Research Center. It directly supports the "Human-Automation Interaction" objective of the Aviation Safety Automation Program.

THE SYSTEM ENGINEERING APPROACH TO COCKPIT DESIGN

One of the most fundamental issues to be addressed in the design of any complex system is the distribution of work between man and machine. Consequently, an effective design philosophy for the use of automation in transport aircraft must clearly define the role of the crew relative to the on-board automation and provide for the most effective use of all available resources. This division of responsibility must be optimized within a broader context that includes other systems with which the aircraft must interface (e.g., other aircraft, airport facilities, air traffic control, etc.).

Within the field of industrial engineering, this division of responsibility is traditionally referred to as the "allocation of functions" between man and machine. Specialists in this field advocate a highly structured approach to the problem of function allocation that is based on thorough analysis of operational requirements and careful assessment of available resources. Particular emphasis is placed on the selective use of automation

to augment human capabilities and compensate for human limitations based on principles derived from the behavioral sciences. According to this design philosophy, function allocation is normally accomplished as an integral part of a larger "system engineering" process.

The term "system engineering," while used widely in the aerospace industry, has no universally accepted definition. System engineering specialists generally use the term to describe a rigorous and highly disciplined development process that is carefully structured to achieve optimum performance of the end product. Though various techniques and procedures are employed to achieve this end, the following general principles characterize the system engineering approach to development:

1. The central focus should be on optimization of total system performance rather than on components.

2. Optimum system performance requires effective utilization of all available resources, (i.e., hardware, software, personnel, etc.).

3. Design requirements should be based on a thorough analysis of the mission to be accomplished.

4. Design criteria should be stated explicitly and applied consistently throughout the development process.

5. The process of system design and integration should be iterative with appropriate use of testing at each stage of development to evaluate alternatives and resolve critical, high risk design issues.

6. Design decisions should be documented in a manner that allows effective configuration control and traceability of design features with regard to mission requirements.

The illustration in Figure 1 provides a simplified model of the system engineering approach applied to the problem of cockpit design. According to this scheme, a thorough analysis of system functional requirements and available technology provides the basis for the initial design. The functions are then allocated between human and automation based on the relative capabilities and limitations of these resources. Design alternatives are assessed through the application of criteria derived from the mission requirements, resulting in the establishment of a baseline cockpit configuration. As the detailed design emerges, its effectiveness is evaluated using analytical and empirical techniques. These evaluations may result in modifications to the baseline design and/or function allocation. The evaluation process employs test methods of increasing fidelity to refine and integrate system components as the design evolves.

The iterative nature of this process is intended to create a high degree of confidence that the final design will function effectively under all anticipated operational conditions. This inherently conservative approach is entirely appropriate in cockpit design because of the obvious implications of design deficiencies with regard to flight safety. Note, however, that the engineering resources consumed in making design changes escalate dramatically in the latter stages of development. It is, therefore, imperative that designers apply the most effective analytical methods available to optimize the baseline crew system design, prior to the test and evaluation stage, so that cost and schedule impact can be minimized.

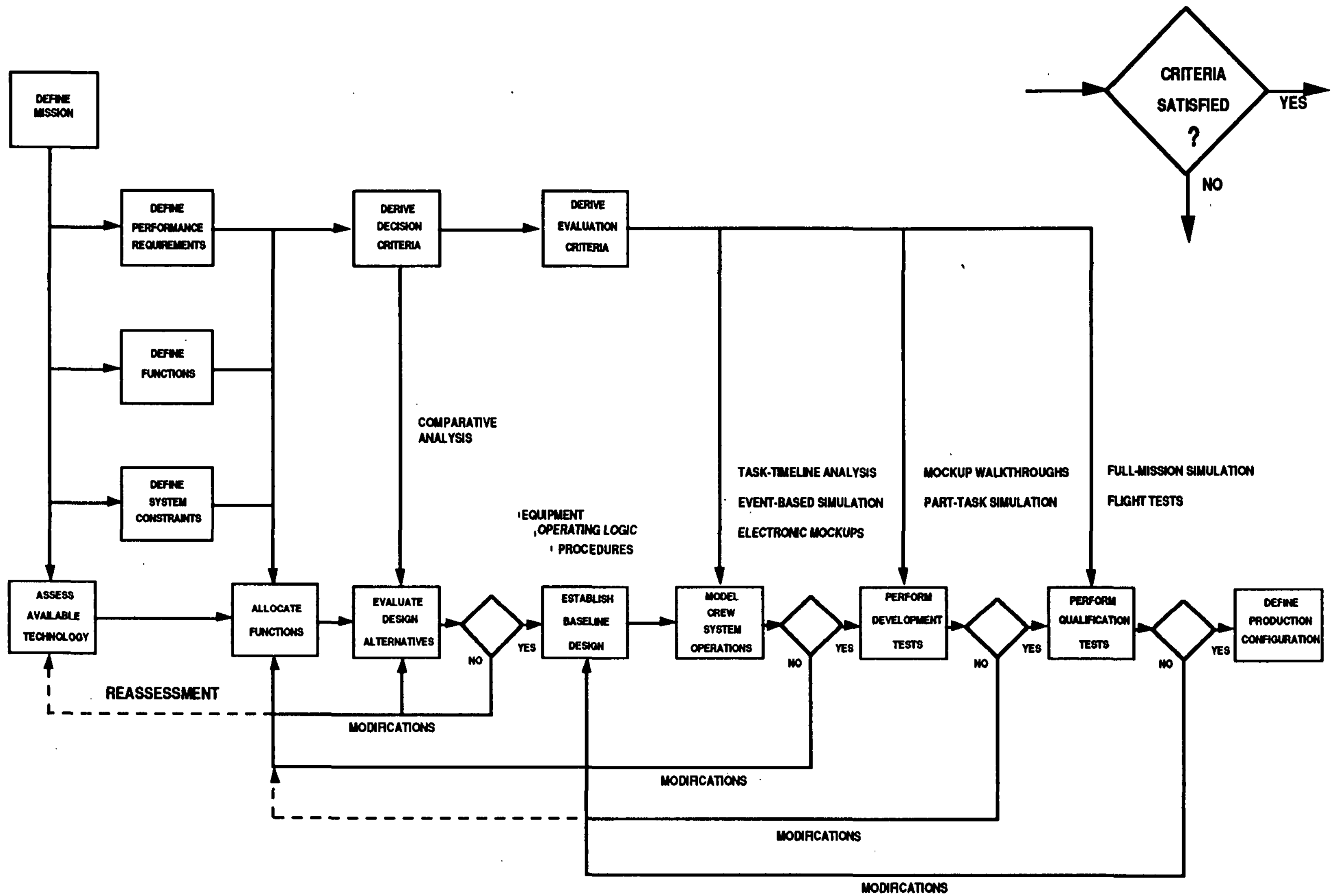

FIGURE 1. A SYSTEM ENGINEERING PROCESS FOR COCKPIT DEVELOPMENT

While system engineering techniques have been employed to varying degrees in the development of some military systems, they have not been used extensively for commercial transport aircraft cockpit development. This is due, in large measure, to the lack of a practical and cost-effective methodology for deriving and documenting functional requirements in a form that is useful for function allocation.

In this document, we investigate two approaches to function analysis and to function allocation. Our objective is to promote human-centered automation. Human-centered automation is that automation that takes account of the capabilities and limitations of the human component of the system in the partitioning of tasks among the flight crew and the remainder of the system, such that overall system performance is optimized. Function allocation criteria, based on principles of human factors engineering and Aviation Psychology, provide a formal mechanism for incorporating a human-centered design philosophy into the system development process.

FUNCTIONAL ANALYSIS OF THE COMMERCIAL FLIGHT DOMAIN

The primary objective of this project was to develop a practical analytical technique for deriving functional requirements and to apply this method to a representative subset of commercial flight operations. The analysis was based on a typical domestic passenger flight of a wide body transport aircraft. The flight scenarios also included a number of abnormal and emergency conditions that could occur during such a flight along with the associated emergency procedures and/or corrective actions. To insure the accuracy and completeness of the functional description, two different methods were employed in its development. The baseline description was generated through extrapolation from an existing task-timeline database for a contemporary transport aircraft. This process, which will be referred to as the "bottom-up" method, required the analyst to make inferences from the task-timeline data regarding the underlying functional requirements. The functions were then organized sequentially within a hierarchical structure of flight phases and segments. The alternative method employed a rigorous "top down" analytical procedure based on the USAF Function Modeling Method, IDEFø (ref. 3). Since time and resources did not permit the accomplishment of two complete analyses of the entire scenario, the IDEFø method was applied only to a limited subset of the flight scenarios. The functional descriptions generated were compared and contrasted to ascertain the relative strengths and weaknesses of the two methods.

A secondary objective of the project was to develop a preliminary concept for using such a functional description as a basis for function allocation in future commercial transport aircraft. This required the establishment of a set of allocation criteria (i.e., decision rules) and a process for applying them systematically to yield an initial function allocation decision. Two alternative concepts for the function allocation process were developed. These processes were demonstrated in hypothetical applications.

The remainder of this report describes the rationale, methods employed and findings obtained from the functional analysis. Conclusions and recommendations are provided regarding the potential benefits and practical utility of applying functional analysis techniques in the design of future commercial aircraft cockpits.

TECHNICAL APPROACH

OVERVIEW

The project roadmap illustrated in Figure 2 shows the basic work flow and sequence of activities that were undertaken to achieve the project objectives. The figure also identifies some of the more significant outputs and products generated at each stage of the effort.

The first stage in the process was to identify and detail an appropriate mission scenario. The particular flight profile was selected to exercise the full range of functional requirements that are typical for a modern, wide body transport aircraft operating on a domestic route. A number of representative emergency and abnormal conditions were also selected for analysis. The basic scenario was then decomposed into a hierarchical structure consisting of periods, phases and segments to provide an overall organizing framework for the detailed functional analysis.

Two different approaches were investigated for extracting the cockpit-related functions necessary to accomplish the mission. The baseline approach used an existing task-timeline database (consisting of a detailed listing of flight crew activities) as a point of departure for the analysis. The analyst attempted to infer the underlying functional requirements associated with each crew task. This largely inductive process was called the "Bottom-Up Approach." The alternative strategy employed a rigorous, rule-based analytical procedure known as IDEFø to decompose the higher level functions into their constituent elements. The functional description was then documented in the form of hierarchical block diagrams with supporting narrative descriptions. This largely deductive process was called the "Top-Down Approach." The two functional descriptions were compared to ascertain the relative strengths and weaknesses of the two methods. The comparison also provided a mechanism to help assure the accuracy and completeness of the baseline functional description.

A review of prior research was accomplished as the initial step in the process to develop a viable function allocation methodology.* Lessons learned from previous experience provided valuable insights to assist in the definition of a useful knowledge representation scheme to support the function allocation process. The literature also provided a source of general principles to guide the development of meaningful function allocation criteria and decision rules.

Two alternative function allocation methodologies were developed. Method A was a somewhat idealized approach that might be accomplished as an integral part of a comprehensive and well structured system engineering process. Method B was explored as an abbreviated, less costly approach that might be used as an expedient alternative in circumstances where limited resources or time constraints precludes the use of more elaborate methods. The two methods were subjected to a trial application using a subset of the data from the baseline functional description. The two methods were compared and contrasted in terms of their logic, internal consistency, content validity and practical utility. Conclusions and recommendations were generated

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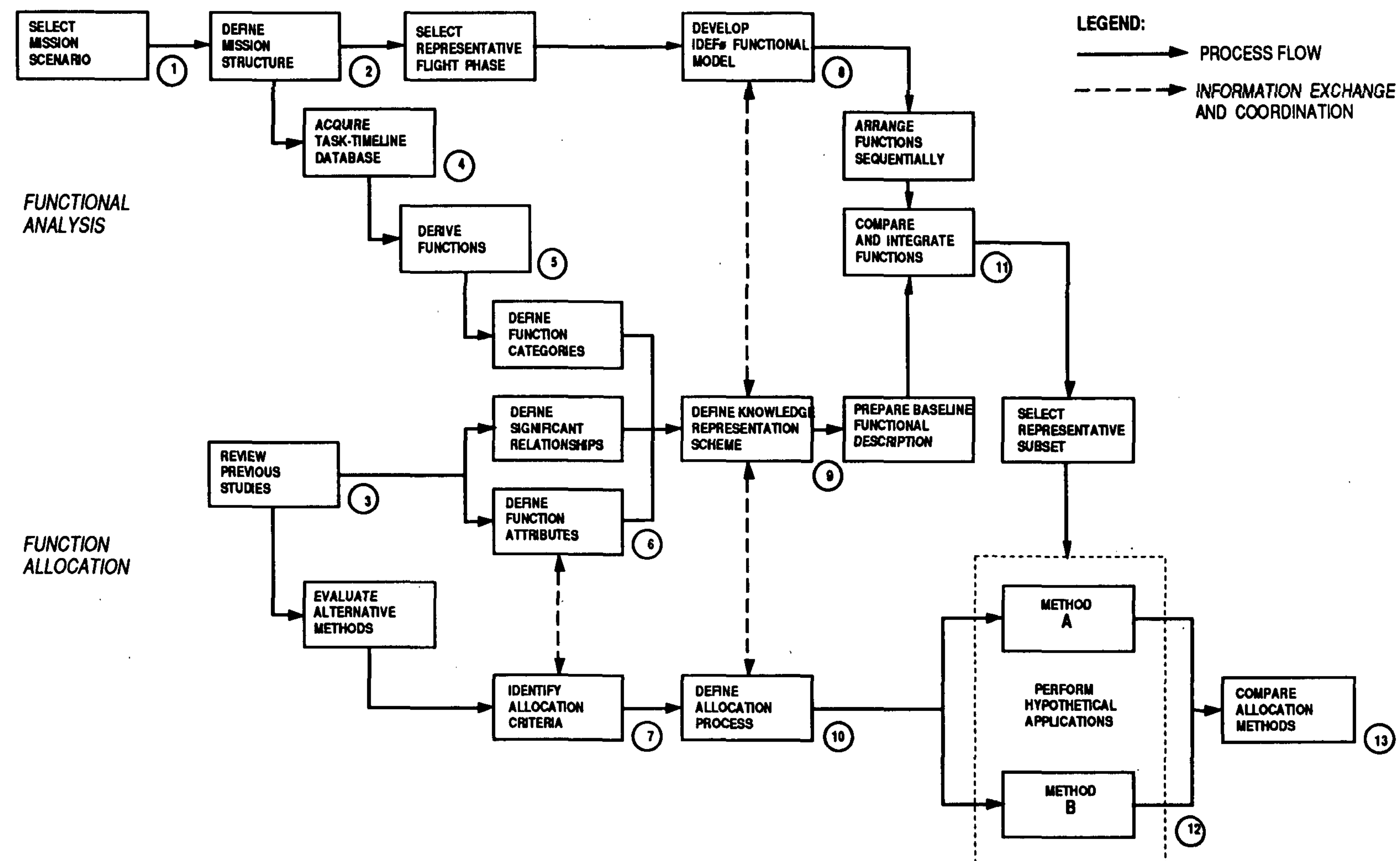
* A summary of relevant literature on the subject of functional analysis methods is contained in Appendix A.



OUTPUTS / PRODUCTS

1. MISSION NARRATIVE, FLIGHT PROFILE, FLIGHT ROUTE, CONTINGENCY LISTING
2. MISSION HIERARCHY
3. LITERATURE REVIEW
4. TASK-TIMELINE DATA
5. FUNCTION LISTING
6. CODING SCHEME, DATABASE REQUIREMENTS
7. DECISION RULES
8. IDEF$_0$ DIAGRAMS, NODE INDEX, GLOSSARY
9. DATABASE FORMAT
10. ALLOCATION PROCEDURES
11. FUNCTIONAL DESCRIPTION, COMPARATIVE LISTING
12. SAMPLE ALLOCATIONS
13. COMPARATIVE ASSESSMENT

FIGURE 2. PROJECT ROADMAP: FUNCTIONAL ANALYSIS OF THE COMMERCIAL FLIGHT DOMAIN FOR FUNCTION ALLOCATION

regarding the potential applicability of functional analysis methods in development of cockpits for future aircraft.

The remainder of this section describes the flight scenario, functional analysis methodology, and function allocation methodology.

FLIGHT SCENARIO DESCRIPTION

The flight scenario selected represents a typical wide-body tri-jet commercial transport aircraft flying in daylight from Los Angeles International Airport (LAX) to John F. Kennedy International Airport (JFK) in New York. This mission was also selected because a detailed task-timeline (TTL) database for most flight crew activities had previously been developed and validated in full-mission simulation.

The mission scenario was synthesized from data available in the TTL database, supplemented with information obtained from Douglas flight operations personnel. Figure 3 is an example of a print-out from the TTL database.

SUBTASK SUMMARY				DATE: 11/15/89
MISSION: MI1			ANALYTICAL FLIGHT MODEL, LAX TO JFK,	
PH11		TAKEOFF		
PH11		**** XA	CALL FOR TAXI CLEARANCE-BEGIN TAXI	
PH11	1	**AA80	REQUEST TAXI CLEARANCE	
PH11	1	AAS001	CAPT CALLS FOR TAXI CLEARANCE	(C)
		* "CALL FOR TAXI CLEARANCE"		
PH11	1	AAB002	FO HEARS CAPT	(FO)
PH11	1	AAB003	FO REACHES LEFT HAND TO AUDIO PANEL SWITCH	(FO)
PH11	1	CXA031	OBS VHF 1 ACTIVE SET TO GND CONTL FREQ (121.65)	
PH11	1	CXA027	ADJ VHF 1 VOL CONT TO COMF AUDIO LEVEL	(FO)
PH11	1	AAB005	RETURN LEFT HAND TO REST	(FO)
PH11	1	CTA001	MOVES RIGHT HAND TO PTT BUTTON ON WHEEL	(FO)
PH11	1	CTA002	PUSH PTT BUTTON FOR TRANSMISSION	(FO)
PH11	1	AAB006	FO TRANSMITS REQUEST TO GROUND CONTROL	(FO)
		* "LAX GROUND CONTROL,	DACO 010—REQUEST TAXI INSTRUCTIONS"	
PH11	1	AAB007	CAPT HEARS FO'S REQUEST	(C)
PH11	1	CTA005	RELEASE PTT SWITCH	(FO)
PH11	1	CTA006	RETURN RIGHT HAND TO REST	(FO)
PH11	1	**CRA8	COMMUNICATION (REC) - LAX GROUND CONTROL	(C, FO)
PH11	1	CR8001	CAPT HEARS ATC MESSAGE	(C)
		* **SEE FOOTNOTES		

FIGURE 3. EXAMPLE OF TASK-TIMELINE DATABASE PRINTOUT

The horizontal flight profile, shown in Figure 4, identifies the waypoints along the flight path prescribed by the flight plan. In Figure 4, the solid triangles represent waypoints. Most waypoints are VORTAC navigation aids. Some (CREEP, BOGGE, COPES) represent intersections of radials from VORTAC stations. In Figure 4, TOC is an abbreviation for Top of Climb. Similarly, TOD means Top of Descent.

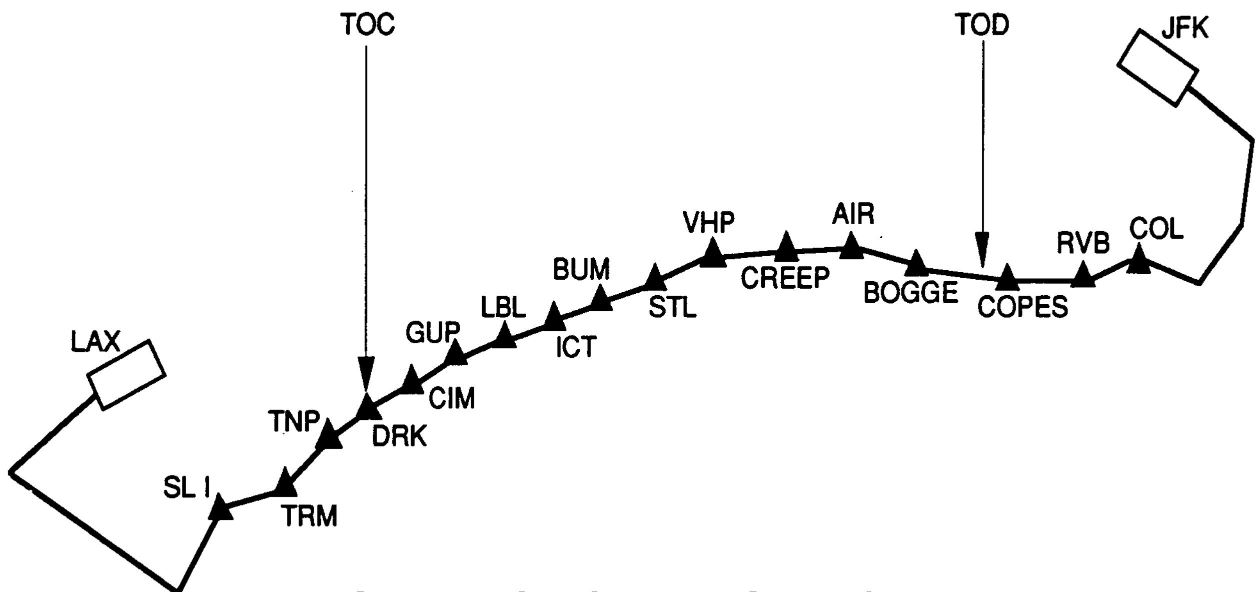


FIGURE 4. HORIZONTAL FLIGHT PROFILE

Figure 5 shows the altitude profile for the mission.

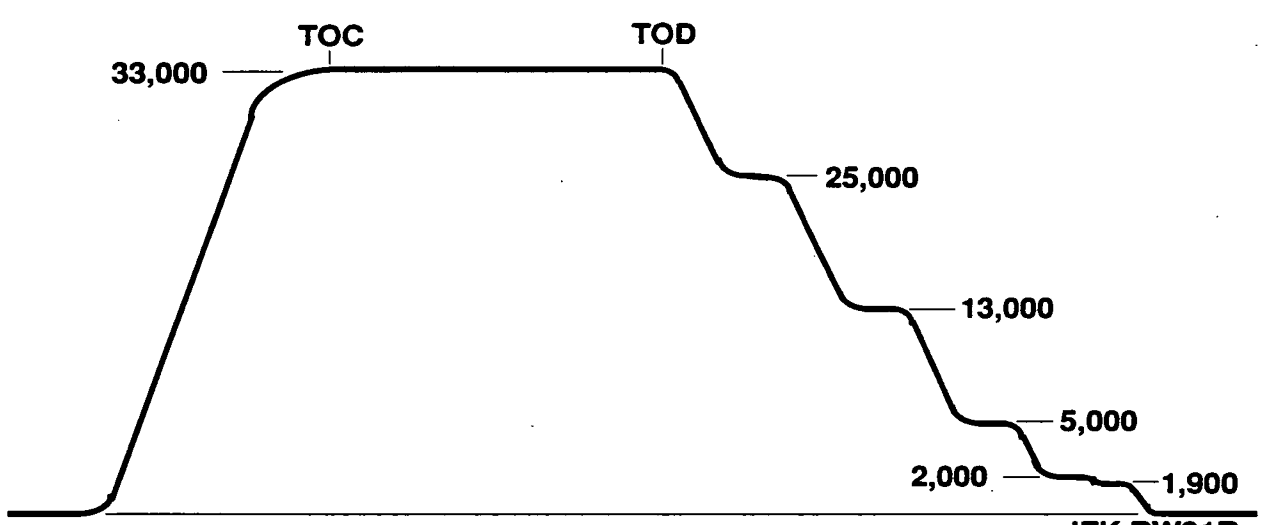


FIGURE 5. ALTITUDE PROFILE

The mission was divided into periods to facilitate analysis. These periods were Pre-Departure, Departure, Enroute, and Arrival. Each period was further partitioned into activities to be accomplished during the period. Figure 6 shows the relationships among mission periods and mission phases.

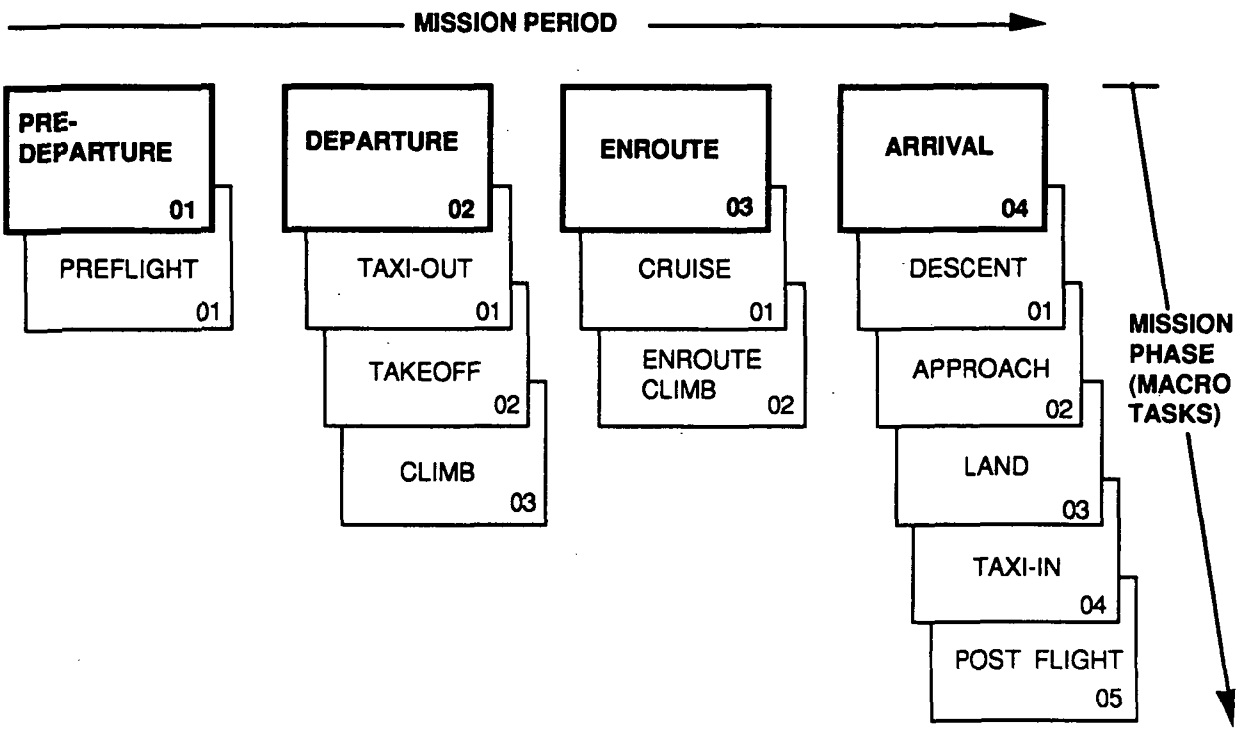


FIGURE 6. MISSION DECOMPOSITION AND STRUCTURE

Figure 7 gives a narrative description of the mission.

In addition to the normal mission, a selected group of contingency situations was considered. The contingencies selected involved several major aircraft subsystems. Different levels of criticality were examined. The analysis concentrated on the most serious contingency situations. The selected contingencies and levels of criticality are shown in Figure 8.

MISSION SCENARIO

The basic scenario consists of a daylight, non-stop, commercial, transcontinental flight originating at Los Angeles International Airport (LAX) and terminating at New York International Airport (JFK). The weather at LAX is fair with temperature at 60° Fahrenheit, visibility at 3 miles, and cloud cover between 500 and 4000 feet. The weather at JFK is fair with temperatures at 50° Fahrenheit, visibility at 2 miles, and cloud cover between 400 and 3000 feet. Runway conditions are dry, and the winds are light and variable for the landing. All aircraft systems function normally throughout the flight.

The scenario begins with preparation of the flight plan. Once the planning and preparation are completed, the flight plan is submitted to Air Traffic Control (ATC), where it is accepted without amendments.

The scenario next moves to the aircraft, where exterior and interior inspections are completed, then system initialization and activation are accomplished.

Once the aircraft is cleared for departure, it pushes back from the departure gate and taxis toward the active runway. At the runway threshold, the aircraft awaits position and holding clearance. After receiving clearance, the aircraft enters the active runway and is positioned for takeoff. After receiving takeoff clearance, the aircraft executes a rolling takeoff on a heading of 249° and ascends to an altitude of 3000 feet where it turns to a heading of 114°. The aircraft continues to climb until it reaches 10,000 feet, where it turns to a heading of 040° and begins tracking to SLI VORTAC. Ascent continues and when the aircraft crosses SLI VORTAC, it turns to a heading of 080° and begins tracking to TRM VORTAC. The climb continues and when the aircraft crosses TRM VORTAC, it turns to a heading of 037° and begins tracking to TNP VORTAC. Ascent continues and, when the aircraft crosses TNP VORTAC, it turns to 060° and begins tracking to DRK VORTAC while completing its final ascent segment. The aircraft levels off at 33,000 feet and is placed in a cruise configuration.

During the cruise phase, the aircraft navigates from waypoint to waypoint. Communications are passed from control center to control center as the aircraft makes its way across the country. The following waypoints are tracked in order after DRK: GUP, CIM, LBL, ICI, BUM, STL, VHP, CREEP, AIR and BOGGE. After crossing BOGGE, the aircraft begins tracking to COPES VORTAC. While proceeding
toward COPES, the aircraft reaches the end of its cruise phase and begins to descend.

Descent proceeds in a stepwise fashion from waypoint to waypoint. AT 18,000 feet, altimeters are set for local altitude. At 13,000 feet, the aircraft crosses COPES VORTAC. Here it turns toward and begins tracking to RVB VORTAC. At 10,000 feet, the aircraft crosses RVB VORTAC. It turns toward and begins tracking to COL VORTAC. At 5,000 feet the aircraft crosses COL VORTAC and turns toward the initial approach fix (IAF). At 2,000 feet, the aircraft intercepts the initial approach fix. Here the aircraft turns toward the intermediate approach fix. After crossing the intermediate approach fix, the aircraft turns toward the final approach fix (FAF). At 1900 feet the aircraft levels off and maintains altitude at 1900 feet until it intercepts the final approach fix. Here the aircraft turns toward the arrival runway and begins the final approach descent. All descents and pre-landing checks are completed, and the aircraft is configured for a normal landing.

The aircraft makes a normal landing and then taxis off the active runway. Following ground control instructions, the aircraft taxis to the arrival gate where passengers are disembarked. All aircraft systems are deactivated, and the aircraft is secured for a layover. Here the scenario ends.

FIGURE 7. NARRATIVE MISSION DESCRIPTION

System / Category	Contingency Description	Level		
		1	2	3
Electrical	Smoke of unknown origin Loss of all generators	* *		
Engine	Engine fire	*		
Fuel	Fuel dump			*
Gear	Main gear extension failure		*	
Hydraulics	Hydraulic system failure	*		
Environmental	Windshear / microburst	*		

1—Emergency condition requiring immediate awareness / corrective action.

2—Abnormal system or condition requiring immediate awareness and subsequent corrective action.

3—Imposes no limitation on aircraft or safety of flight

FIGURE 8. CONTINGENCIES

FUNCTIONAL DESCRIPTION

The Statement of Work for Contract NAS1-18028 called for a two-pronged approach. The bottom-up approach was initiated first. It is based on detailed knowledge of the activities required of crew members as the aircraft accomplishes its mission. The top-down approach proceeds from a statement of the objective of the aircraft system and systematically decomposes the top objective into the activities logically necessary to its accomplishment. This systematic decomposition of activities to greater and greater levels of detail results in a hierarchy of functions, each of which is logically necessary to the accomplishment of the next higher level function.

At the outset, it is well to state clearly what automation was assumed, if any, and the effect of that assumption on the functional decomposition. The "Bottom-Up" approach is based on an existing task time line (TTL) database, used to assess flight crew workload as part of the certification process for a new aircraft. The crew procedures are based on a specific design. The detailed nature of the procedures is evident from Figure 3. It was assumed that one could infer from the TTL database the functional requirements that had been implemented during the design process. Its content could be influenced by the existing allocations. The analysts attempted to eliminate references to any specific design implementstion while preserving the

underlying functions. A comparison with a "Top-Down" approach showed that, for a given flight segment, similar functions were identified.

The "Top-down" approach applied during this contract assumed that the analyst is dealing with a transport aircraft, but the details of the design are not present (in the commercial aircraft world, the new aircraft would probably have many commonalities with the aircraft it is replacing. This helps to minimize production and logistic support costs). In an IDEFø model, an allocation is indicated by an arrow entering the function box from below. The arrow label tells what the mechanism is (a piece of equipment, a computer program, or a person). The IDEFø model created for this effort has no mechanisms. This means that no allocation has been made or assumed.

Two different groups of researchers independently developed and applied the function allocation techniques. Method A was developed by Search Technology, Inc. Method B was developed by Douglas Aircraft Company.

Bottom-Up Approach

The bottom-up approach began with the acquisition of task-timeline data that describes the flight crew activities for various operations of a contemporary wide body aircraft. The data aids in the certification of transport aircraft by the FAA. The data provides very detailed information about the tasks that must be accomplished by the flight crew. This data has certain limitations when applied to a functional analysis. With the TTL data the focus is upon aircrew workload within the context of a specific aircraft design, where the allocation decisions have already been accomplished and a design implementation has been selected. The TTL data therefore recounts in detail how the aircrew performs their tasks while interacting with a defined hardware and software design configuration. The functional requirement that is the basis for this task accomplishment is missing. Also missing are the activities performed by system automation that interfaces with the crew. A further shortcoming of the TTL data is that it begins and ends at the active runway. Given the limitations noted above, it was therefore necessary to build substantially upon the existing TTL data.

The first modification to the existing TTL data involved restructuring it into a four-level hierarchy consisting of Mission, Periods, Phases, and Segments. This restructuring permitted selective retrieval and sorting of the data. The highest level is Mission. This allows for future expansion of the database into multiple mission scenarios. Period and Phase are lower level logical divisions of the data, with Segment being the lowest division. Along with this hierarchical restructuring, each segment was identified by the milestone event that initiated its performance. Preflight and postflight information was missing from the TTL data. The hierarchy was expanded to provide a location for this data as it became available. Figure 9 shows this expanded mission structure.

MISSION HIERARCHY STRUCTURE

PERIOD	PHASE	SEGMENT
PRE-DEPT 01	PRE-FLIGHT 01	01 PLANNING AND PREPARATION
		02 SYSTEMS INITIATION
		03 SYSTEMS ACTIVATION
DEPARTURE 02	TAXI-OUT 01	01 GATE DISENGAGEMENT
		02 DEPARTURE TAXI
		03 PREPOSITION HOLDING
		04 POSITION HOLDING
	TAKE-OFF 02	01 TAKE-OFF GROUND ROLL
		02 LIFTOFF
		03 INITIAL ASCENT
		04 TRANSITION / ACCELERATION
		05 ASCENT TO 3000 MSL
	CLIMB 03	01 ASCENT TO 10,000 FEET MSL
		02 ASCENT TO 18000 FEET FT MSL
		03 ASCENT TO DEPT WAYPOINT (SLI)
		04 ASCENT TO DEPT WAYPOINT (TRM)
		05 ASCENT TO DEPT WAYPOINT (TNP)
		06 ASCENT TO CRUISE ALTITUDE
ENROUTE 03	CRUISE 04	01 FLIGHT TO WAYPOINT: DRK VORTAC
		02 FLIGHT TO WAYPOINT: GUP VORTAC
		03 FLIGHT TO WAYPOINT: CIM VORTAC
		04 FLIGHT TO WAYPOINT: LBL VORTAC
		05 FLIGHT TO WAYPOINT: ICT VORTAC
		06 FLIGHT TO WAYPOINT: BUM VORTAC
		07 FLIGHT TO WAYPOINT: STL VORTAC
		08 FLIGHT TO WAYPOINT: VHP VORTAC
		09 FLIGHT TO CREEP INTERSECTION
		10 FLIGHT TO WAYPOINT: AIR VORTAC
		11 FLIGHT TO BOGGE INTERSECTION
		12 FLIGHT TO TOP OF DESCENT (TOD)
ARRIVAL 04	DESCENT 01	01 DESCENT TO FL 250
		02 DESCENT TO 18000 FEET MSL
		03 DESCENT TO 13000 FEET MSL
		04 DESCENT TO 10000 FEET MSL
		05 DESCENT TO 5000 FEET MSL
		06 DESCENT TO IAF
	APP 02	01 DESCENT TO INTERMEDIATE APP FIX
		02 DESCENT TO OUTER MARKER
	LAND 03	01 DESCENT TO DECISION HEIGHT
		02 DESCENT TO TOUCHDOWN
		03 LANDING GROUND ROLL
	TAXI-IN 04	01 TAXI TO RAMP
		02 GATE ENGAGEMENT
	POST FLT 05	01 SYSTEMS SHUTDOWN

FIGURE 9. MISSION HIERARCHY STRUCTURE

The task data was converted into a functional description. The first step was to create an action verb list. This list served to constrain verb usage to a mutually exclusive, predefined set. The objective was to insure consistency of usage. Appendix B contains the complete action verb list. The next step was the development of a list of generic aircraft systems. This list served to standardize the objects upon which the action verbs operated. Appendix C contains the generic aircraft system list. With these lists in hand, construction of the decomposition database could proceed. Segment by segment the task data was converted to its functional equivalent. Aircrew operating procedures, aircraft flight manuals, and subject matter experts were consulted to provide supplemental data. These resources also helped to ensure the validity of the analysis. Automated systems activities and preflight and postflight operations, missing from the original TTL data, were identified and stated as functions.

Once functional decomposition was completed for the normal flight scenario, the contingencies were approached in a similar fashion. Here, however, decomposition was accomplished outside the context of any specific mission hierarchy. This was done for the sake of flexibility. It was envisioned that as the database is expanded in the future, an analyst would want to experiment with the introduction of failures at various points in a mission. Figure 8, shown in an earlier section, shows a listing of the contingencies that were addressed during this effort.

At this point, it was decided that an attempt would be made to expand the decomposition database to include descriptive characteristics associated with the functions, such as time constraints, initiating or terminating cues, performance standards, and functional attributes, if such data were available or could be developed. It was also decided that the focus of the expansion should be in a flight critical area such as takeoff or landing. The liftoff segment was subsequently chosen as a test case and various methods of characterizing the functions were explored.

The first performance classification scheme that was developed identified the performance schedule required for the function. Three schedules were defined: discrete, intermittent and continuous. Discrete functions were those which required single non-recurrent performance, such as activating or deactivating a system or component. Intermittent functions were those which required multiple, recurrent performance, such as periodically monitoring a display. Continuous functions were those which required variable but uninterrupted performance, such as controlling aircraft heading or speed.

An additional performance classification scheme was developed that identified functions according to the nature of the process involved in their performance. Four basic categories were established: information, decision, action, and communication. The information category included those functions that involved the search for and receipt of sensory information. The decision category included those functions that involved information processing, problem solving, and decision making. The action category included those functions that involved control of the aircraft and its systems. The communication category includes those functions that involved the transmission and reception of messages, information, and instructions, both internal to, as well as external to, the aircraft.

Having established the viability of these performance classification schemes, attention was turned toward assessing and defining the relationships between functions and events that might affect functional

performance. The goal was to identify performance cues and timing constraints that would further define functional performance limits. This analysis uncovered performance dependencies between events and functions, as well as among functions themselves.

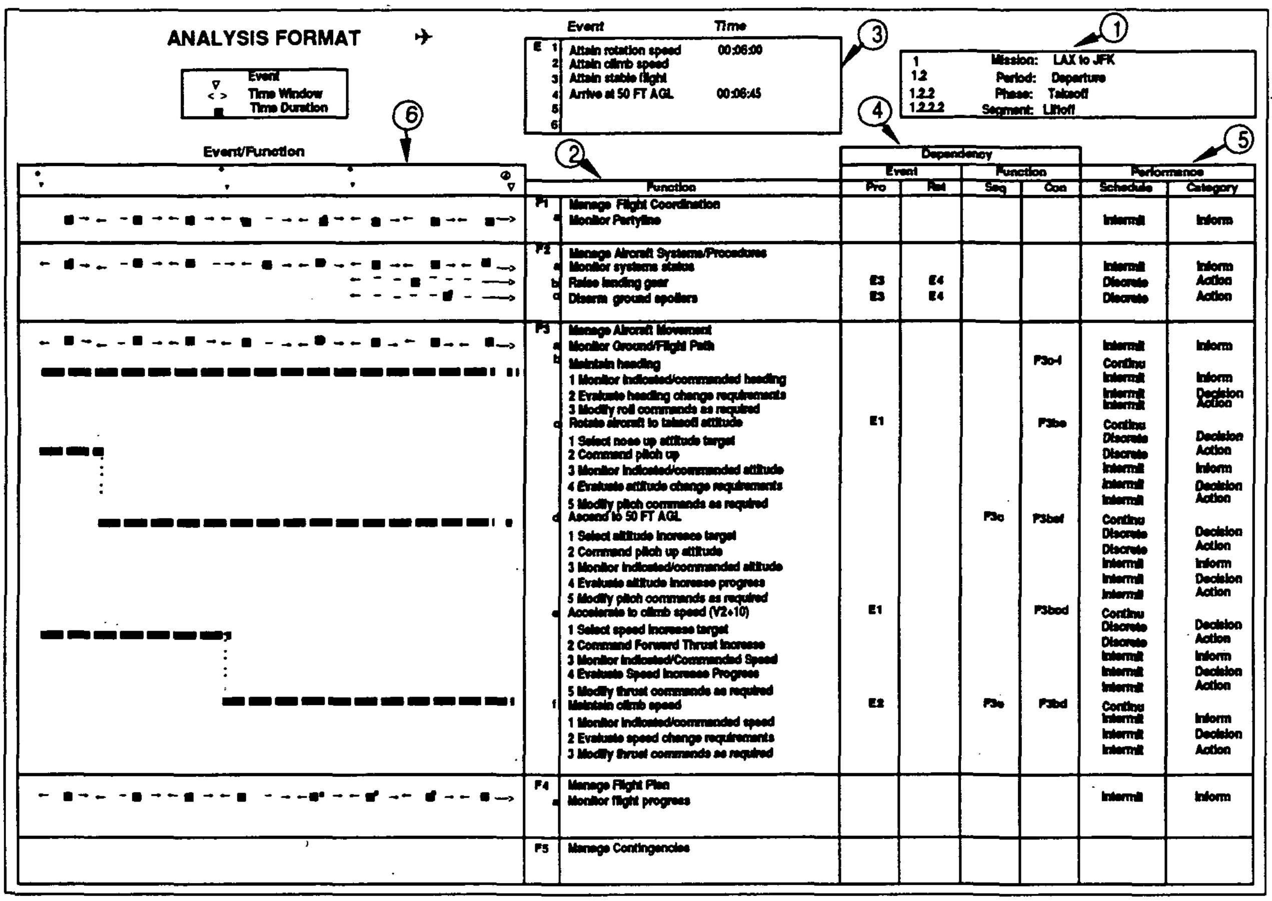
Event dependencies were found to exist whereby the performance of a function was contingent upon the occurrence of a referenced event. Where a function could not be initiated until the occurrence of a referenced event, this was termed proactive dependency. For example, the aircraft can not be rotated until a velocity milestone is reached. Where a function had to be completed before the occurrence of a referenced event, this was termed retroactive dependency. For example, all before landing preparations must be completed before actual weight-on-wheels at touchdown occurs.

Dependencies were also found to exist between functions whereby the performance of one function was in some way dependent upon the performance of another function. These dependency relationships were found to be either sequential or concurrent in nature. Sequential dependency was found to exist where one function had to be completed before another could be initiated. For example, communications with a particular ATC station cannot be established until that station is tuned in. Concurrent dependency was found to exist when functions had to be performed at the same time. For example, velocity, altitude, and heading must all be simultaneously controlled while the aircraft is airborne. These dependency relationships are summarized in Table I.

TABLE I — DEPENDENCY RELATIONSHIPS

DEPENDENCY	RELATIONSHIP
Proactive	FUNCTION enabled by an EVENT occurrence
Retroactive	FUNCTION must be completed prior to an EVENT occurrence
Sequential	FUNCTION enabled by completion of another FUNCTION
Concurrent	FUNCTION occurs in parallel with another FUNCTION

Various methods of depicting these event and function dependency relationships were explored. A purely tabular representation was inadequate, particularly where concurrent dependencies existed. It therefore became necessary to provide a graphical representation as well as a tabular representation, to capture the true nature of these dependency relationships. The liftoff segment was depicted accordingly and is shown in Figure 10, Analysis Format. The functions shown here were extracted from the original decomposition database. In the original database, functions were listed sequentially, as they were expected to occur. Here, however, related functions are grouped together. Figure 11, Primary Function Categories, shows this grouping strategy. Then, within each grouping, functions are listed sequentially.



1. This box identifies the segment's location within the mission hierarchy.

2. This column identifies the functions which must be accomplished within this segment. Each is coded by an "F" designation.

3. This box identifies the events which are relevant to this segment. Each is coded by an "E" designation.

4. These columns identify the dependency relationships which exist between events and functions, and those which exist among functions. The "F" and "E" designations which appear within the cells are those noted in numbers 2 and 3 above.

5. These columns identify the performance schedule and performance category associated with each function as discussed above. Complete definitions of the terms are found in Appendix D, Glossary.

6. This area represents an event by function matrix which graphically displays the dependency relationships which were alphanumerically coded, as described in number 4 above. The numbers along the top refer to the "E" designations noted in number 2 above.

FIGURE 10. ANALYSIS FORMAT

MANAGE FLIGHT COORDINATION

- Maintain External Coordination
- Maintain Internal Coordination

MANAGE AIRCRAFT SYSTEMS/PROCEDURES

- Perform Normal Operations/Procedures
- Perform Contingency Operations/Procedures

MANAGE AIRCRAFT MOVEMENT

- Control Velocity
- Control Altitude
- Control Attitude
- Control Heading

MANAGE FLIGHT PLAN

- Develop Flight Plan
- Follow Flight Plan
- Modify Flight Plan

MANAGE CONTINGENCIES

- Plan For Contingencies
- Initiate Contingency Procedures
- Monitor Contingency Procedures
- Terminate Contingency Procedures

FIGURE 11. PRIMARY FUNCTION CATEGORIES

The events that are shown here also require some explanation. The first event represents the milestone that initiates this segment, while the last event represents the milestone that terminates this segment and initiates the next segment. These were also taken from the original decomposition database. However, the intervening events shown here are new and were identified during the event-to-function dependency analysis described above. One should also note the times associated with the first and last events in the event box. These times were derived from the TTL data and reflect the mission scenario upon which this decomposition was based. These are the only time references that are available at this time and they are expected to be fairly representative of a typical transport aircraft. By contrast, the intervening events have no time reference since they are dependent upon aircraft design requirements, which at this time are not well defined. Likewise, the duration of the functions is driven by aircraft system design and is not known at this time. However, it is possible to determine the windows of opportunity for function performance, given the event and function relationships, and this is what is shown in the graphic on the left side of Figure 10.

Let us examine the graphic representation. As noted above, along the top of the graphic are enclosed numbers that refer to the event coding scheme. Combining this event data with the function data from the middle of the format produces an event by function matrix that allows one to establish the windows of opportunity for each function, based on event and function dependencies. When dealing with discrete or intermittent functions, the space within the arrows indicates the window or windows of opportunity for function performance, while the solid box located within the window represents the performance duration of the function. As noted above, these function durations are not known at this time. The boxes just indicate that the function must be accomplished somewhere within that time window, and that the duration will likely be less than, but may never exceed, the available time window. The multiple windows shown for intermittent functions are used to indicate that the functions are performed periodically. The frequency is unknown at this time, but the format is used to convey the repetitive nature of the function. When dealing with continuous functions, the window of opportunity is equal to the performance duration, so the two are not differentiated and a continuous series of filled boxes is used to indicate this.

As the design proceeds, and hardware and software are specified, the data for window size, performance duration and frequency will become available. They could then be included in the database and used as a basis for subsequent workload studies. It is also expected that as additional functional definition is available and allocation is accomplished, additional columns would be added to the right of this format. Thus, while confining the format to the available data, provision has been made for necessary expansion of the database in the future.

Once the utility of this analysis format was established, this scheme was applied to the segments of the decomposition database that occur between gate disengagement before taxiing for takeoff until gate engagement following landing at the end of the flight. As noted above, it was decided to maintain the integrity of the original decomposition database, so function data was extracted from it and then analyzed separately. However, after the analysis format effort was completed, the data that had been established for intermediate events, as well as the modifications to the functions that resulted from this analysis, were fed back into the decomposition database to enhance its accuracy. Three separate databases therefore resulted from this bottom-up effort: a normal flight file which includes the complete mission (see Appendix E), a contingency file that includes all the contingency data, (see Appendix F), and the analysis format files (see Appendix G). These files were generated in the Microsoft Excel spreadsheet program. It was envisioned that these files could be transferred to a more powerful database management system such as ACIUS 4th Dimension, if required later.

Top-Down Approach

The Structured Analysis and Design Technique (ref. 24) was selected by the U. S. Air Force to describe the functional architecture of manufacturing. To accommodate copyright restrictions, the name was changed to IDEFø (ref. 3). The technique provides a structured, disciplined approach to the decomposition of a top objective into the hierarchy of functions that are necessary to the accomplishment of the top objective. For this reason, it is particularly well suited to the creation of a functional description of the objective "Accomplish Commercial Transport Missions." The method assures that every lower level function is logically necessary to the accomplishment of a higher level function. It also identifies the data associated with each function at each

level of decomposition. IDEFø does not address time or sequence, which are essential to the preparation of a timeline. Other methods must be used to address these dimensions of the analysis.

IDEFø syntax—The syntax used in this method is very simple. It consists only of boxes and arrows. Boxes represent functions, objectives, or activities. Functions are always active verbs or verb phrases (e.g., Start Engines). Arrows are data. They represent "things." They are always labeled with a noun or noun phrase, and can be any "thing," including people. There are four kinds of arrows: Input, Output, Control, and Mechanism. As shown in Figure 12, Input arrows enter the function box from the left; Output arrows leave the box from the right side; Control arrows enter the box from the top; Mechanism arrows enter the box from the bottom. Inputs are converted to Outputs by Mechanisms, subject to the constraints imposed by Controls. Existence of a Mechanism arrow implies that an allocation has been made. For this reason, Mechanism arrows are initially omitted from the top down decomposition. Additional characteristics of the method are listed in Table II. An IDEFø model includes diagrams, glossary and text. A Glossary is prepared for each diagram, if the diagram contains terms not previously defined. Because of the complexity of the decomposition in this report, Glossary entries have been repeated for ease of presentation and utility. The text is a brief description of what the diagram is intended to show and is usually only a short paragraph. It is important to understand that labels on data arrows are explicit, but legends in function boxes are not. One understands what a function box contains only when the box is decomposed into its major constituent activities. For this reason, text does not describe what is in a function box.

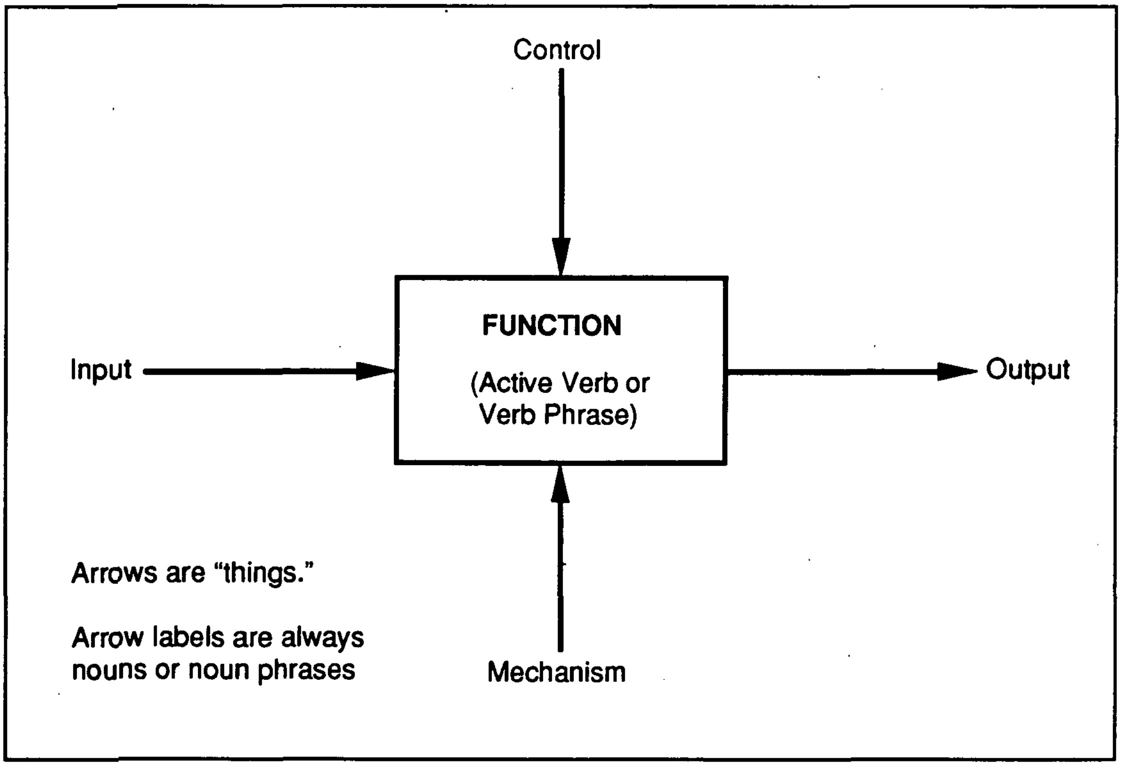


FIGURE 12. IDEFø SYNTAX

TABLE II — SOME CHARACTERISTICS OF IDEF$_{\emptyset}$

- Top-down, structured decomposition
- General at the top level; detail increases with decomposition
- Shows interfaces among activities on same diagram
- Allows for concurrent activities and iteration
- Allows feedback from output to controls or inputs
- Does not address time or sequence
- No less than three, no more than six boxes on a diagram
- Every term must be defined
- Promotes unambiguous communication
- Developed using author/reader cycle (iterative)
- A kind of knowledge acquisition tool

Development of the model—Inputs to the development of the IDEFø model included the mission as given in Figures 4, 5, 6, and 7, and the mission hierarchy structure given in Figure 9. The model was created by an analyst experienced in the use of the method and with extensive experience as a flight deck crew member in high-performance jet aircraft. Elements of the model were created manually, then entered into Meta Software design/IDEF, running on a Macintosh II workstation.

The purpose of preparing the IDEFø model was to assure that the top-down and bottom-up methods achieved comparable results, from the standpoint of identifying similar functions at the detail level. For this reason, development concentrated on the branch of the architecture leading to the liftoff segment of the mission profile. In Figure 9, this means moving from the Departure Period to the Take-off Phase to the Liftoff Segment. To arrive at this level of detail requires the creation of many diagrams. This is evident from Figure 13 that shows a portion of the Node Index for the model. Each Node Number represents a diagram. Indentation shows the subordination of the diagram in the hierarchy. A complete Node Index to the model is given at the beginning of Appendix H.

Figure 14, A-0, is the top of the model, "Accomplish Commercial Transport Missions." It shows the major Input, Control and Output data, the purpose for creating the model and the viewpoint from which the model was created. In the development of an IDEFø model, the viewpoint should be that of the end user of the model and may not be changed in the course of development without adversely affecting validity. The top of the model has the node number "A-0." The node number uniquely identifies the diagram and shows its position in the hierarchy. The A-0 diagram is referred to as the "Context" diagram because it delimits the scope of the model.

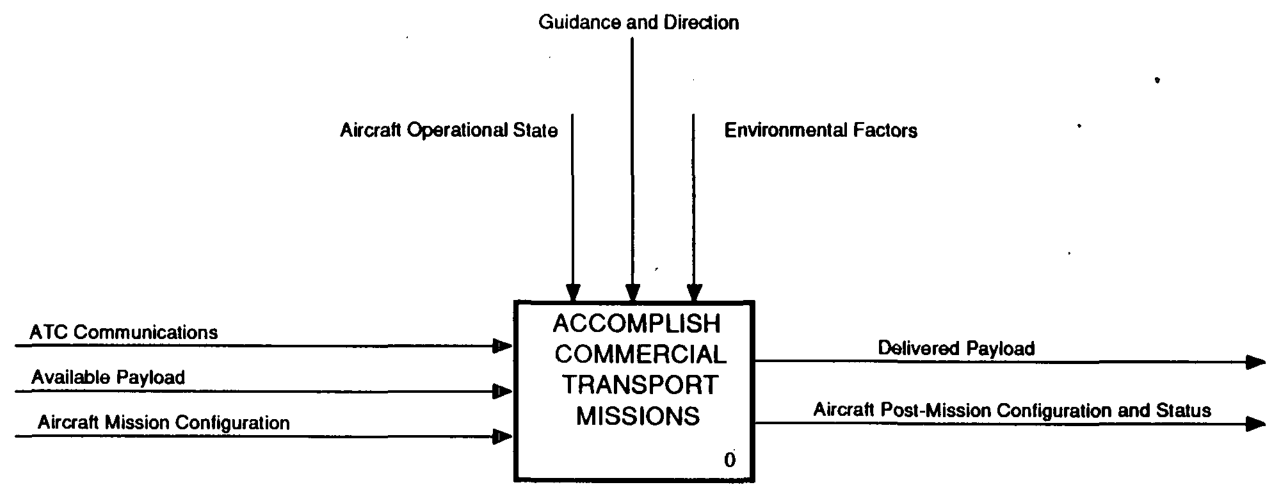
USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 10/2/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

A-0 ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS
A0 ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS
- A1 PERFORM PRE-DEPARTURE ACTIVITIES
- A2 PERFORM DEPARTURE-RELATED ACTIVITIES
  - A21 ACCOMPLISH BEFORE TAXI ACTIVITIES
    - A211 ACCOMPLISH BEFORE START/PUSHBACK
    - A212 PERFORM ENGINE START
    - A213 PERFORM AFTER START ACTIVITIES
  - A22 PERFORM TAXI OUT
    - A221 PERFORM TAXI
    - A222 PERFORM BEFORE TAKEOFF ACTIVITIES
  - A23 PERFORM TAKEOFF
    - A231 COMMUNICATE DURING TAKEOFF
    - A232 CONTROL AIRCRAFT DURING TAKEOFF
      - A2321 CAPTURE AIRCRAFT FLIGHT DATA
      - A2322 CONTROL AIRCRAFT ATTITUDE
        - A23221 CONTROL AIRCRAFT PITCH ANGLE & RATE
        - A23222 CONTROL AIRCRAFT ROLL ANGLE & RATE
        - A23223 CONTROL AIRCRAFT YAW
      - A2323 CONTROL AIRCRAFT AIRSPEED
        - A23231 MONITOR/VERIFY AIRSPEED
        - A23232 SELECT AIRSPEED CHANGE OPTIONS
        - A23233 COMMAND AIRSPEED INCREASE
        - A23234 COMMAND AIRSPEED DECREASE
        - A23235 COMMAND THRUST, DRAG, ATTITUDE CHANGE

NODE: FACT / T2	TITLE: NODE INDEX: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG-002

FIGURE 13. PORTION OF NODE INDEX

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/13/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: NONE



PURPOSE:
To define the functional activities that relate to the performance of a commercial flight mission

VIEWPOINT:
Crew Systems Operations Specialist

NODE: FACT A-0	TITLE: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG-01

FIGURE 14. CONTEXT DIAGRAM, A-0

Figure 15 shows the major constituent activities of A-0. It has the same title as A-0 because it includes the same content as A-0. Below this level, a diagram will bear the title of the parent box of which it represents the decomposition. Diagram A0 shows the interfaces among the major activities that make up the model. This is the only level at which these interfaces are evident. Below this level, it is not possible to go from sibling to sibling; one must come back to A0 to see the relationship.

Figure 15 shows the same major activities as addressed by the "Bottom-Up" approach, but also includes the function "Manage Contingencies." Contingencies may arise in any mission period (Pre-Departure, Departure, Enroute, Arrival). The response to accomplish management of the contingency is tailored appropriately.

The complete IDEFø model is contained in Appendix H of this report. For a better understanding of the IDEFø modeling method, the reader is invited to review reference 3.

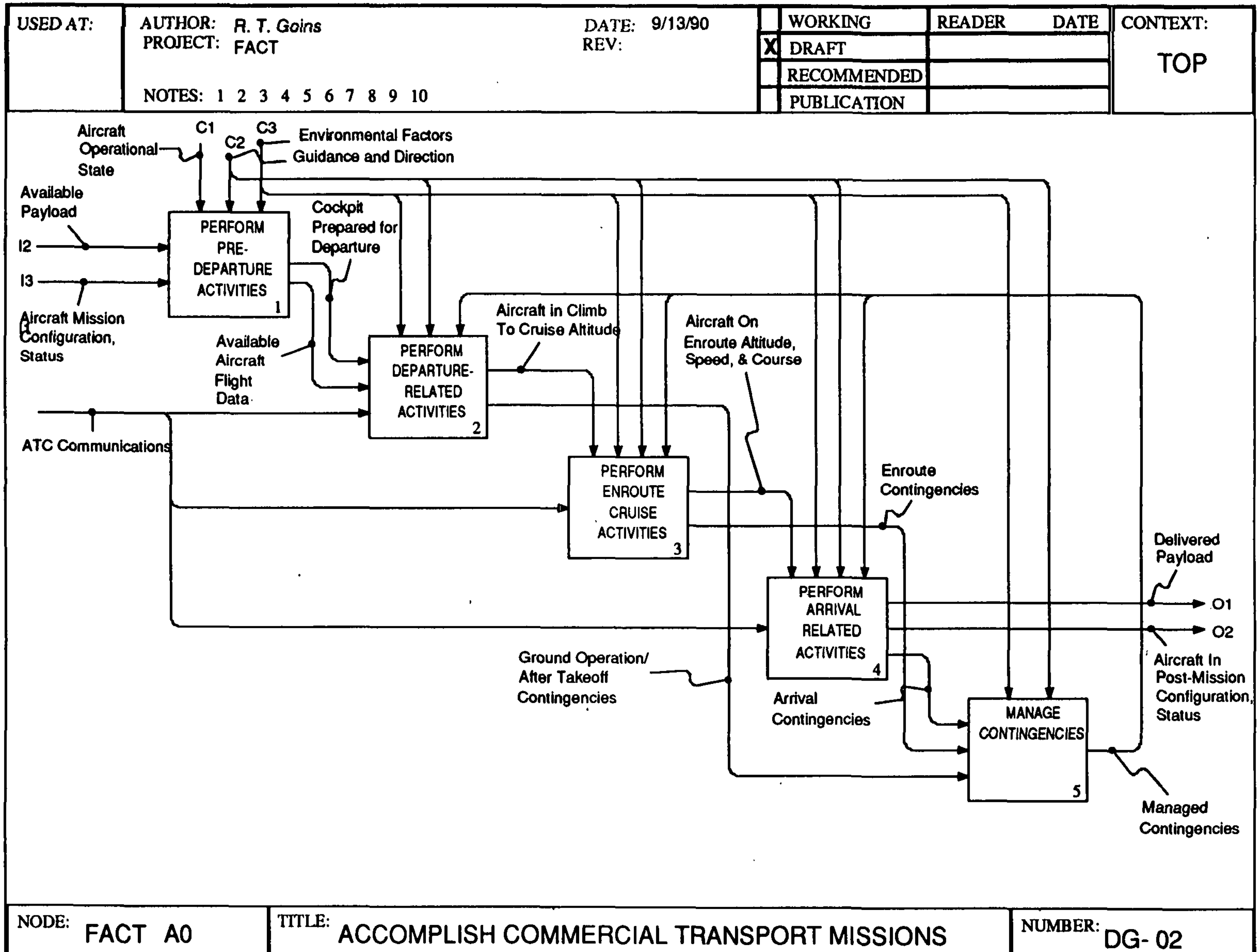


FIGURE 15. FIRST LEVEL DECOMPOSITION, A0

FUNCTION ALLOCATION

While many authors have dealt with the subject of function allocation at a general philosophical level, available literature provides little guidance to the design engineer regarding specific procedures or criteria for making decisions about function allocation in the context of system development. Two very different approaches to function allocation were applied to the functional decomposition of the flight from LAX to JFK. Each method offers significant insights regarding the general problem of function allocation and its specific application to the commercial flight domain.

The first approach to function allocation, Method A, employs a progressive, iterative decision process that is intended to be integrated with full scale system engineering efforts. The methodology assumes that function allocation needs to influence the design decision process at every stage of a development effort - from the initial design requirements to design implementation, and finally to all activities from prototyping to production. This method also explicitly incorporates a "human-centered" approach to allocation, viewing the human operator as a multidimensional resouce whose cognitive and performance characteristics must directly influence the allocation process. This method also encourages the development of adaptive allocation schemes capable of making on-line function allocation decisions responsive to situation-specific changes on the flight deck.

In contrast to the extensive, iterative process proposed in Method A, the second approach to function allocation, Method B, is a relatively brief, simplified system designed to provide an effective first cut allocation. Method B comprises two components: A set of decision criteria diagnostic of a function's most appropriate allocation, and a rule system which acts on inputs from the decision criteria to yield initial allocations. This rule system is designed to capitalize on the relative importance and context-sensitivity of the decision criteria in its determinations of effective allocations. In this respect, Method B, while necessarily being limited in scope, affords the designer a relatively useful allocation scheme — as well as a comparatively practical, straightforward approach to defining an initial allocation that permits the designer to proceed to more detailed and definitive evaluations.

Method A: Heuristic/Iterative Process

Our first function allocation methodology is based on the work of Rouse and Cody (ref. 4) at Search Technology, Inc. Considering the entire design process, these authors reacted to textbook descriptions that depict design as a linear progression of steps from functional requirements definition through final design. In these idealizations, once functional requirements are defined, one then determines which functions can be provided by technology and which will be provided by crew members. Various lists of guidelines (e.g., Fitts, ref. 5), are available to support allocation decisions. The underlying assumption in the textbook view is that once allocation is settled, integration and detailed design can proceed without further concern for allocation.

Rouse (ref. 4) argued that this assumption is unrealistic for two reasons. First, it is unlikely that, for a system of any complexity, a single pass through allocation will yield an acceptable final allocation solution. Second, allocation cannot be performed in isolation from design because the viability of the allocation scheme depends

on its implementation details. That is, to know whether an allocation will be acceptable or not, one must design the system to a sufficient level of detail to permit evaluation of both human and automation performance with respect to performance requirements. Therefore, the allocation process, in practice, is difficult to separate from design and evaluation.

In recognition of these deficiencies, Rouse and Cody (ref. 4) proposed a multi-phase design process in which allocation, equipment design and evaluation are pursued repeatedly. The methodology differs from conventional textbook approaches in three ways. First, it recognizes that allocation decisions cannot be made independently of design and evaluation and, therefore, promotes iteration among these three activities. Second, it emphasizes a psychological basis for allocation decisions and task design. The human operator is considered to be a multidimensional resource whose performance and workload can be controlled by integrating functions with complementary requirements and separating functions with competing requirements. Third, the methodology encourages adaptive allocation schemes that blend human and automation resources such that task assignment decisions are made on-line.

In the following sections, we first review this allocation methodology, and then define its information and support requirements. Next we describe an integrated support system based on these requirements. We then offer an example to illustrate the methodology and show how the proposed support system would behave. Finally, we suggest how the support system functionality might be implemented with existing microprocessor-based software and recommend development areas for an advanced and fully integrated system.

Overview

The focus of the procedure described in this section is the function allocation portion of each iteration of the allocation-design-evaluation process. However, as suggested above, it is necessary to present the material on allocation in the context of its relationships with design and evaluation. Therefore, while design and evaluation are not treated in great detail in this discussion, the points of interaction of allocation, design and evaluation are given considerable attention.

Figure 16 depicts the overall methodology in terms of four phases, each of which is composed of several steps. The *functional requirements definition* phase is aimed at developing a representation of functional demands that can occur during the mission of concern and that are candidates for allocation to human or automation resources. The present methodology assumes that this representation is a function timeline (Table III) about which much more is discussed below. When the timeline has been defined, three passes through the allocation-design-evaluation cycle are pursued.

During *initial design*, the objective is to develop a preliminary but comprehensive treatment of the allocation problem by posing an allocation and then predicting performance for each function that is allocated to the human crew. The emphasis in this phase is on single-task performance under different mission conditions.

In the *design integration* phase, opportunities to combine complementary tasks and to separate tasks that compete for human resources at the same time are identified and addressed.

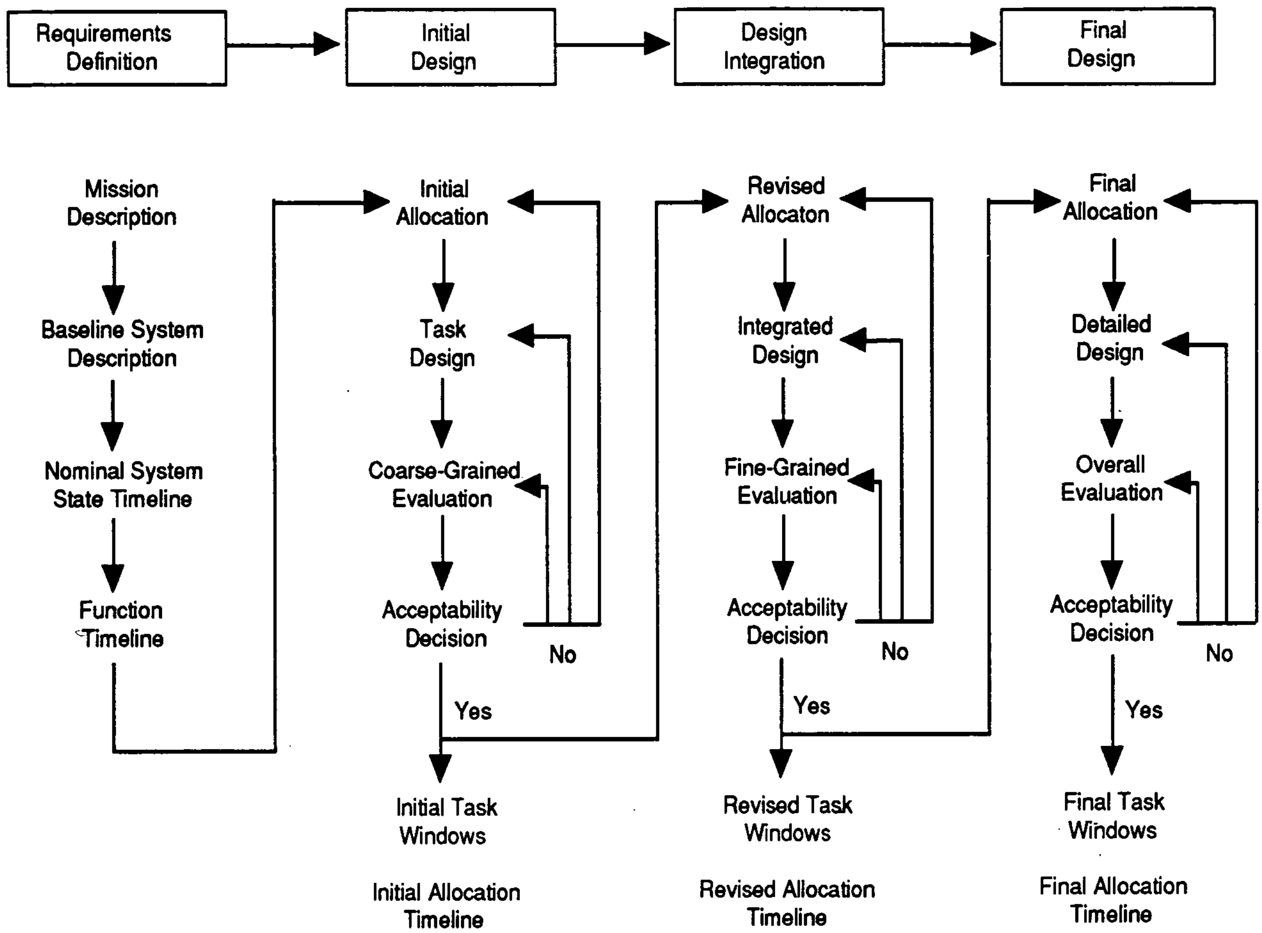


FIGURE 16. OVERALL FUNCTION ALLOCATION METHODOLOGY

TABLE III - FUNCTION TIMELINE

Mission Interval	Desired Elapsed Time	Desired Vehicle Time	Subsystem State	Function	Performance Criteria	Function Criticality	Allocation

Mission Interval = Identity of mission period, phase and segment Elapsed Time = Nominal time (M:S) from mission start at which system states should occur.

Desired States = Vehicle position, airspeed, etc., and subsystem modes and settings that should be in effect at each elapsed time interval of interest. States define intermediate "milestones" to be achieved and environmental conditions that are expected to affect human performance.

Function = Allocatable entities that become tasks once displays, controls and procedures are defined.

Performance Criteria = Maximum allowable values of time, errors, or inefficiencies for acceptable task performance; specific measures are task dependent.

Function Criticality = Relative importance of performing the associated function. Includes urgency.

Allocation = Resource (human, automation, or both) to which function will be assigned as a result of the methodology.

Final design resolves all allocation decisions that had been postponed during earlier phases, considers dynamic allocation schemes where needed, completes the detailed design, and provides comprehensive system evaluation to ensure that objectives represented in the function timeline can be fully met.

The allocation-design-evaluation cycles convert the function timeline into two outputs:

1. An allocation timeline (Table IV) which specifies, for each time interval, the assignment of each function to either human or automation. To the extent that allocation is dynamic, the timeline specifies the most likely resource.

2. For each function that will be performed by the human crew for at least one time period, a "task window" (Figure 17) that specifies the displays, controls and operating procedures used to effect the function along with the models and data used to predict human performance and support task design.

TABLE IV - ALLOCATION TIMELINE

Mission Element	Elapsed Time	Function 1	Function 2	----	Function N
—	—	A	H	---	A
—	—	A	H	---	A
—	—	X	H	---	A
—	—	X	H		A
		X	H		H
		H	X		H
		H	X		H
		H	X		A
		.	.		
		.	.		
		.	.		

Symbol	Function Allocation
X	Not Required
H	Performed by Human
A	Performed by Automation

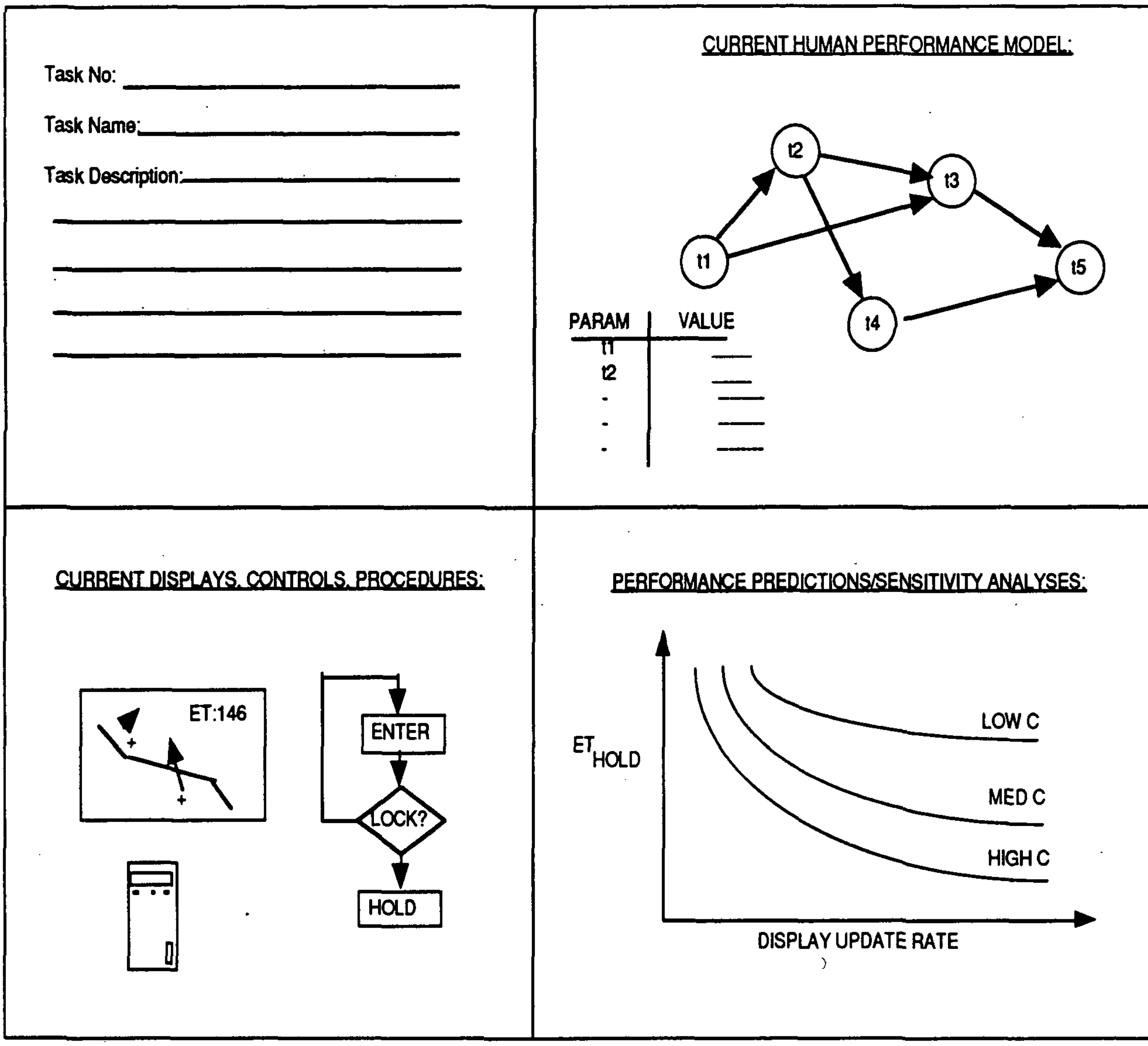


FIGURE 17. EXAMPLE TASK WINDOW

Functional Requirements Definition

To support the allocation methodology, system objectives must be identified and converted into functional requirements. As depicted in Table III, these requirements should be expressed as a timeline in order to be compatible with the allocation methodology. Several aspects of this representation deserve elaboration.

First, the term "function" must be defined. We define a "function" to be a goal-directed activity that must be accomplished successfully to satisfy a mission or system requirement (see glossary of terms). Similarly, "subfunctions" are functions that satisfy higher-level functions.

Over the years, several means for defining functions have emerged. We suspect that, in practice, most design efforts proceed with informal lists of functions that are generated with no particular method. This approach involves the least amount of labor, but the greatest cost in terms of potentially missing key needs.

More recently, formal methods have emerged which prescribe disciplined procedures for defining system functions. For example, the IDEFø method discussed above decomposes functions according to their parent-child relationships. When a higher-level function is decomposed into its major constituent activities, a parent-child relationship is created. The higher-level function (or activity) is the parent. The subordinate functions (or activities) are the children. The method considers only parent-child relationships, i.e., there are no grandparents or other relationships. Functions at the same hierarchical level are associated according to inputs and outputs, but not in terms of temporal or sequential dependencies.

Other function definition approaches annotate functions with temporal and/or sequential dependency information. This approach is most prevalent in schemes that resemble task scheduling in project management. Basically, functions are defined in accord with any convenient or formal method. The major requirement is that each function be distinguishable, whether through the use of naming conventions, numbering schemes such as accompany work-breakdown structures, or any other systematic coding scheme. Given identifiable functions, temporal information and/or dependencies are attached to each function. These additional data "attachments" permit the allocator to identify timing conflicts, causes for delays, the "critical path," and other measures that have emerged from project management concepts.

For our purposes, temporal and sequential dependency data are crucial to our function allocation method. Therefore, as will be elaborated more fully below, we advocate that function specifications include these variables, regardless of the method used to determine their values.

Regardless of the form chosen, the representation of functional requirements should satisfy three criteria:

1. Sufficiency: Satisfaction of all lowest-level functional requirements implies satisfaction of the higher-level functional requirement(s) to which they are attached.

2. Consistency: Satisfaction of one requirement should not preclude satisfaction of other requirements that contribute to the same function.

3. Continuity: All lowest-level subfunctions should be transformable into tasks by defining how they are performed (i.e., defining displays, controls and procedures).

The first two of these specifications are fairly standard across descriptions of function decomposition methods. The third specification assures that the lowest-level subfunctions can be allocated without further functional decomposition. This specification also makes an important distinction to the present methodology between functions and tasks.

As stated above, a function is defined as a goal-directed activity that must be accomplished successfully to satisfy a mission or system requirement. In contrast, a "task" is a specific design instantiation or mechanization

of a function. A task defines how a particular function is performed in terms of displays, controls and procedures. While functions can be allocated to alternative resources, tasks are functions that have been allocated and, specifically, to humans.

A second aspect of the structure in Table III that deserves note is the presumed need for a "function timeline." This structure is premised on functional requirements varying in time, both in terms of whether or not each system function is required at all, and in terms of changing conditions, performance criteria, and criticality to mission success. There are two primary ways in which a function timeline might be generated, each of which has advantages and disadvantages.

One approach is "mission analysis." A written scenario is converted to a mission timeline of desired system and subsystem states. In database parlance, each "record" represents a desired state or snapshot of the system that should prevail if the mission proceeds exactly as planned. Fields associated with each record include the following: (1) mission interval identification (e.g., period, phase, and segment); (2) elapsed time from mission start in time units that are appropriate to the level of analysis required (e.g., minutes and seconds); (3) desired vehicle state (e.g., position, velocity, etc.); and (4) desired subsystem state (e.g., proper mode and setting of each subsystem).

Together, values of these variables at specific instances in time define "milestones" that the system as a whole is supposed to achieve to have a successful mission. Functions then are basically the goal-directed activities that must be performed to change the system and subsystem states from one milestone to the next. Note the temporal granularity with which these milestones are defined should be guided by the allocation requirements task. Therefore, expected task swapping rates between human and automation resources are likely to be the defining condition for how fine the temporal distinctions among milestones must be.

In general, while computer packages are available to support the mission analysis process, it is a labor-intensive task requiring considerable experience and expertise. Beyond the labor involved, there is also the possible disadvantage of placing too heavy an emphasis on one or a few scenarios that may not be representative of the full range of requirements. Further, a large proportion of each scenario will represent periods of low demand and, therefore, investments of analytical effort unlikely to lead to identifying bottlenecks in crew system operability.

An alternative approach is one that focuses directly on critical requirements (MIL-H-46855B in essence advocates this tack for human factors analysis of military systems). Each function is considered in the context of its most taxing conditions. This type of analysis emphasizes worst-case situations independent of particular scenarios. Flight conditions where demands are expected to be relatively benign are given little or no attention, even if these conditions represent opportunities for disengaging automatic systems.

This approach, which might be termed "requirements analysis," has the advantages of being more direct and, thereby, less labor intensive. It does, however, exhibit three disadvantages. First, it ignores the time-varying nature of demands. Second, since the approach avoids comprehensive analysis, it is more likely to miss critical requirements that could not be readily anticipated. Third, is the lack of time synchronization that is inherent in mission analysis. This lack of explicit time-linked relationships can make it difficult to identify co-occurrences

of critical requirements in any systematic manner. As discussed below, identifying co-occurrences is a primary mechanism for integrating related tasks and separating tasks that compete with one another for human resources.

Regardless of the approach used to produce the function timeline (i.e., comprehensive versus focused), the function allocation methodology discussed next is oriented toward producing an allocation scheme that satisfies these demands while maintaining acceptable crew workload.

Initial Design

Figure 18 depicts the procedure for initial design. Numbered boxes refer to procedures and the pointed boxes depict inputs to or outputs from these procedures. (Note: given the variety of methods for producing an acceptable function timeline to start the process, we have not presented a separate flow chart for the requirements definition phase. For this reason, the box numbering scheme in Figure 18 begins with Step 2.1).

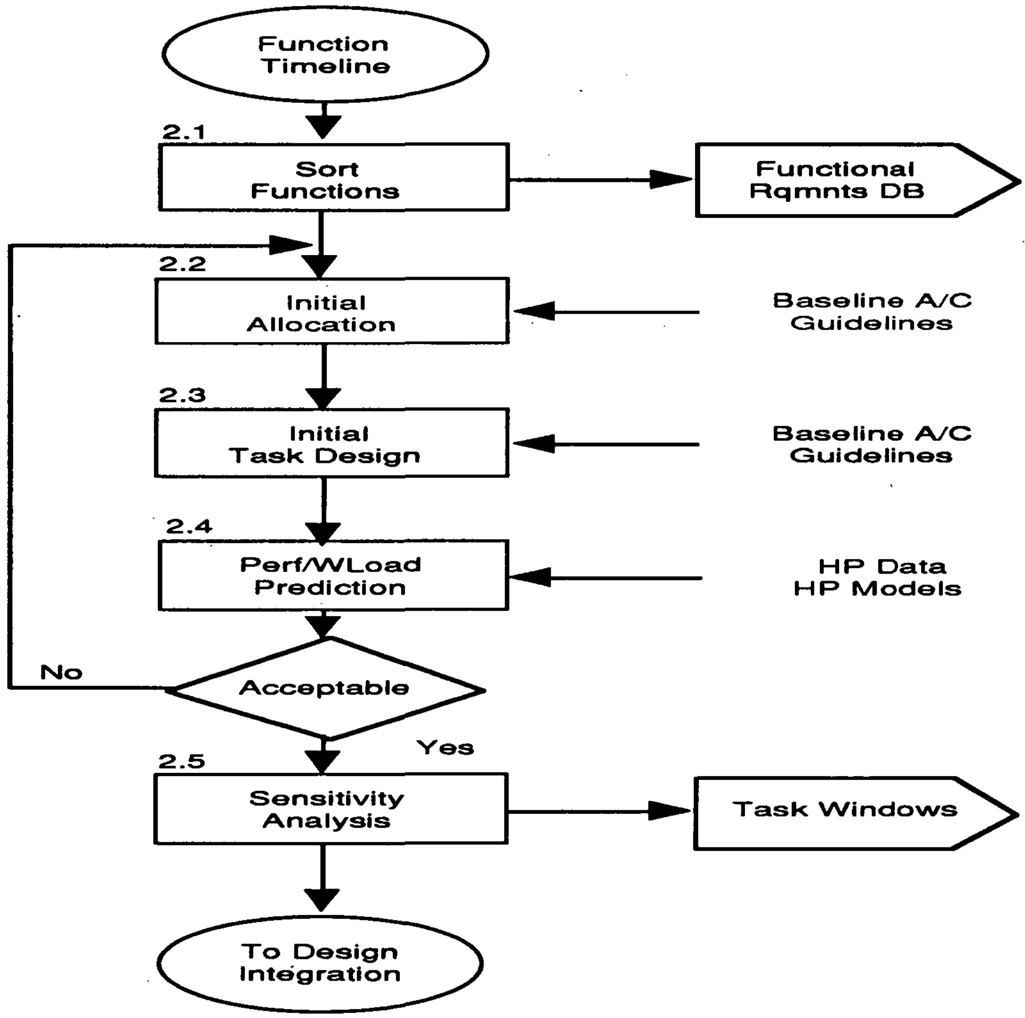


FIGURE 18. INITIAL DESIGN

In initial design, the objective is to develop an approximate but comprehensive scoping of the total allocation problem. It begins by sorting the function timeline by function. This operation produces a list of times during the mission when each function is demanded. What is more important, it reveals the types of conditions (mission intervals and desired system states) and ranges of performance criteria and mission criticalities associated with each function. This look at the functional requirements serves to highlight particularly problematic functions.

Once the functions are sorted, an initial allocation is made using recent designs and allocation guidelines such as those by Fitts (ref. 5) or the Air Force Studies Board (ref. 6). Functions are allocated to humans ("H"), automation ("A"), or potentially both ("H/A"), with a bias toward "H/A" when it is not clear what allocation is most appropriate. "H" and "H/A" functions are then converted to tasks by adopting displays, controls, and procedures from existing aircraft or through design.

The effort to produce these initial task designs would be inordinate were it not for the fact that most of these designs can be based on previous systems. That is, one or more existing designs are likely to be used as baselines to provide nearly all the initial task designs. Although this practice might be criticized as perpetuating past mistakes, two points are important to note. First, initial allocation and design are not final allocation and design; the initial design phase is aimed at developing a reasonable baseline system. Second, relying on past designs is essential to producing new designs within any reasonable cost constraints. Our belief is that it is totally unrealistic to approach crew system design with a "clean slate" philosophy.

With initial task designs in place, estimates of human performance are used to determine whether or not humans could perform these tasks acceptably, independent of the demands of other tasks. A more detailed discussion of the "acceptability decision" is provided below. It is important to emphasize that performance is predicted at this stage rather than assessed (for example, in manned simulation). This substantially lessens the number of ways in which performance can be considered. To the extent that an initial task design resembles the design from a previous system, data collected during the detailed phases of previous design efforts may provide initial estimates of likely human performance in the new system. Alternatively, when these data do not exist, human performance models or engineering judgment become necessary.

With performance projections in hand, one must decide whether the allocation is acceptable. Since this decision is repeated in subsequent design phases, it is elaborated here in Figure 19.

In each instance, this decision is based on a comparison of criteria for a particular function under particular conditions that were specified in the function timeline, and on predictions of human performance for each task allocated to humans ("H") or allocated to both humans and automation ("H/A"). In the event that the criteria are satisfied, the process is quite straightforward. However, if predicted performance is unacceptable, the implications are not intuitively obvious.

As shown in Figure 19, if predicted performance is unacceptable, the first recourse is to consider automation. If technology is available or foreseeable, reallocation is a reasonable choice. Otherwise, the task in question is, at that point at least, a potential problem (denoted by **). However, if performance is only marginally worse or

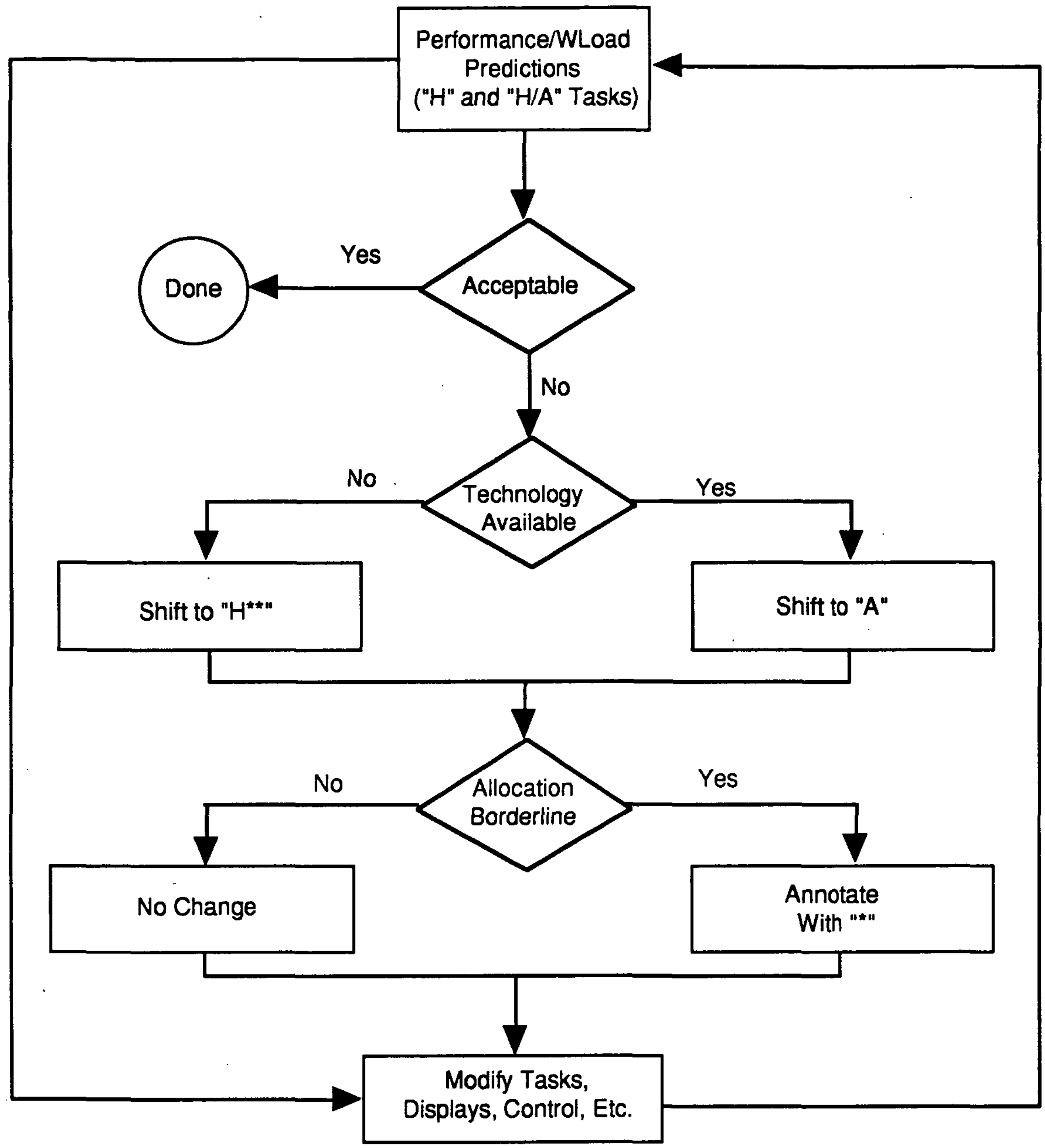


FIGURE 19. ACCEPTABILITY DECISION

better than criterion levels, then the allocation is borderline (denoted by *), and subsequent design and evaluation may change the resulting allocation.

Returning to Figure 18, the last block indicates a sensitivity analysis. This is an important step because the criteria in the function timeline are usually not as definitive as they may appear, and performance predictions always have some associated uncertainty. Thus, it is essential that "hard" decisions not be made where only soft decisions are warranted.

Design Integration

The first pass through the allocation-design-evaluation process yields a baseline crew system that is important as a benchmark. However, this baseline is likely to be very rudimentary in those areas where new concepts and technology are being implemented. In a sense, the innovations that will set the new crew system apart from the old have, thus far, only been "patched in."

The second pass through the allocation-design-evaluation process is summarized in Figures 20 and 21. In contrast with initial design that focuses on single-task performance at different points in time, design integration emphasizes relationships among tasks at similar points in time. We differentiate between complementary tasks and competing tasks. Complementary tasks are those which do not compete for the same resource (e.g., vision) at a given point in time. The primary goals of this phase are to take advantage of complementary relationships among tasks to produce integrated displays, controls and procedures that enhance performance and reduce workload, and to re-design tasks that potentially compete for human resources and impair performance. The process of finding and exploiting potentially complementary tasks is represented in Figure 20 while the process for finding and avoiding potentially competing tasks is represented in Figure 21.

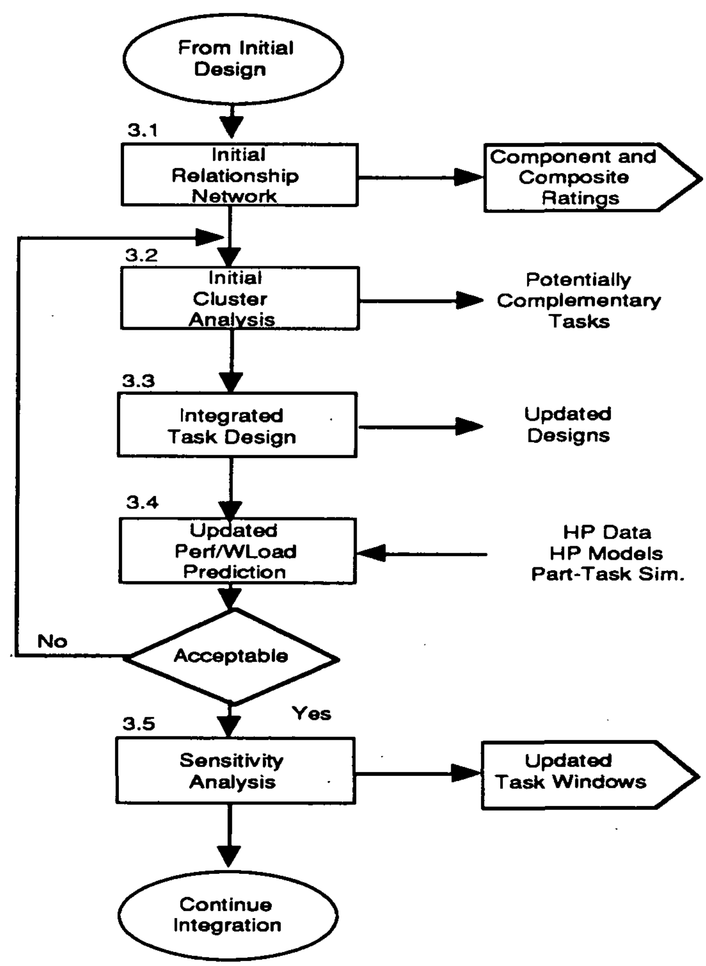


FIGURE 20. DESIGN INTEGRATION-COMPLEMENTARY TASKS

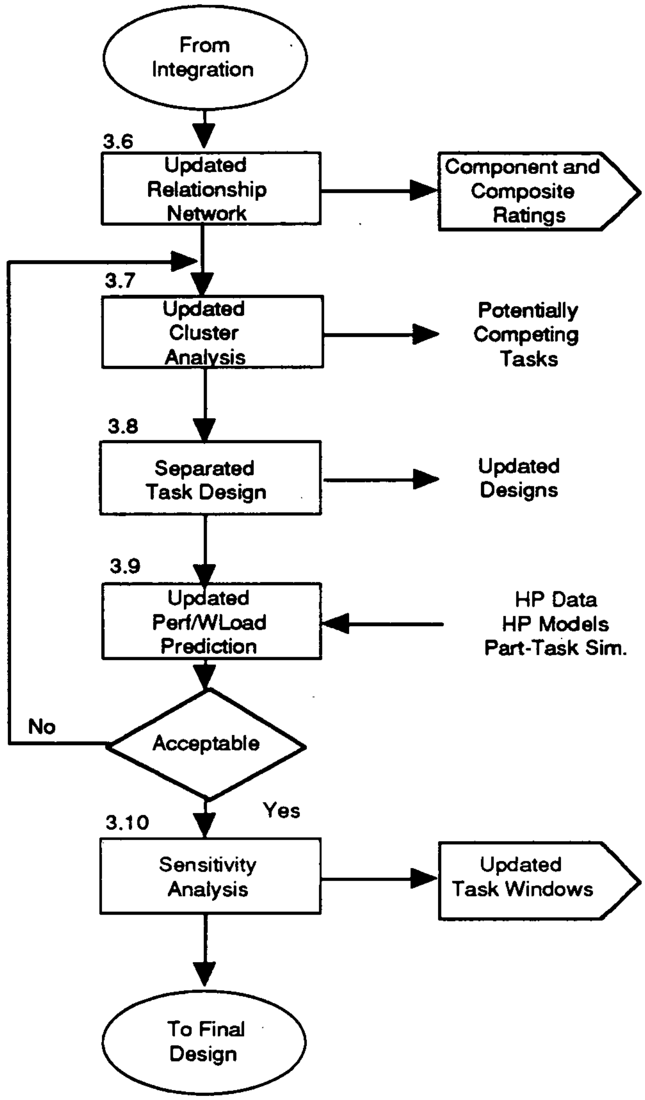


FIGURE 21. DESIGN INTEGRATION - COMPETING TASKS

The first part of design integration begins with a complete review of the initial allocation to find "opportunities" for improving performance. These opportunities are identified in two ways. First, the initial allocation is reviewed with an eye for specific design problems from previous crew systems. This review is likely to be quite cursory unless the previous crew system upon which the initial allocation is based was rife with problems.

Second, relationship networks among all possible pairs of "H" and "H/A" tasks are also constructed to help identify integration opportunities. This approach involves estimating the extent to which the members of each pair of "H" and "H/A" tasks: (1) promote the same system goal; (2) co-occur in association with particular events; (3) involve the same subsystem; or (4) require the same information for their execution. Strong relationships along one or more of these four dimensions signal integration opportunities. Networks can be

viewed directly or be submitted to cluster analysis methods to identify potentially complementary tasks. However, while these techniques may serve as catalysts, engineering judgment is nevertheless still the means to this end.

Given complementary tasks are identified, task windows (see Figure 17) that were developed during initial design are then redesigned. If possible, the complementary tasks are combined to form new, single tasks (e.g., altitude and attitude control might be combined through a velocity vector display). Where tasks cannot be combined, one may attempt to use common display, control or procedural elements (e.g., several attitude displays might be combined into a single display for all complementary tasks).

Evaluation of designs produced in this iteration cannot rely to as great an extent on performance data collected previously for elements of the baseline aircraft. Analytical tools such as human performance models can form a reasonable bridge between these old data and any new empirical efforts. At this point, the primary purpose of these tools is to focus subsequent data collection. For instance, model-based analyses can be used to identify those ranges of design parameters that are most likely to affect human performance.

A variety of empirical methods are likely to be used during this phase. Laboratory-oriented studies, static mockups, and dynamic part-task simulations all have a place in evaluating how well the novel and critical aspects of the new crew system have been designed. The purpose of these evaluations is to provide performance data that will enable comparisons across both the old (baseline) and new elements of the crew system.

Figure 21 depicts the second part of design integration whereby conflicting relationships among tasks are ameliorated. The analytical approach to identifying conflicts is similar to that used for identifying complementary tasks. However, conflicts are, obviously, dealt with differently in that separation of tasks is the goal.

To identify competing tasks, each pair of "H" and "H/A" tasks is examined to determine the extent to which they require the same human processing resources at the same time. Task pairs are rated according to their frequency of co-occurrence and on the extent to which they impose simultaneous demands on input, processing, and output resources of the human crew. Relationship networks and cluster analysis methods support this effort as they did in identifying complementary tasks.

When competing demands are uncovered, task designs are modified in one or more of three basic ways to reduce the competition. First, tasks can be "rescheduled" or shifted in time relative to one another. Second, displays, controls or procedures might be modified to change the nature of the human resource demands (e.g., where the competitors both involve verbally-oriented auditory demands, one might be changed to a spatially-oriented, visual pattern recognition task). Third, when time-shifting and time-modification are not feasible, aiding may be possible (e.g., use of quickened or predictor displays). If all attempts to reduce competition to manageable levels fail, then the methodology recommends re-allocating one or more of the tasks to automation if the necessary technology is available or foreseeable. New task designs that emerge when competing tasks are separated lead to another round of evaluation, performance prediction, and sensitivity analysis.

Final Design

The purpose of the final pass through the allocation-design-evaluation process, depicted in Figure 22, is to produce a final, documented crew system design. All allocation decisions that were based on marginally acceptable or unacceptable human performance or workload are resolved. Final allocation decisions are heavily influenced by whether the general automation philosophy emphasizes defaulting to manual or automatic control.

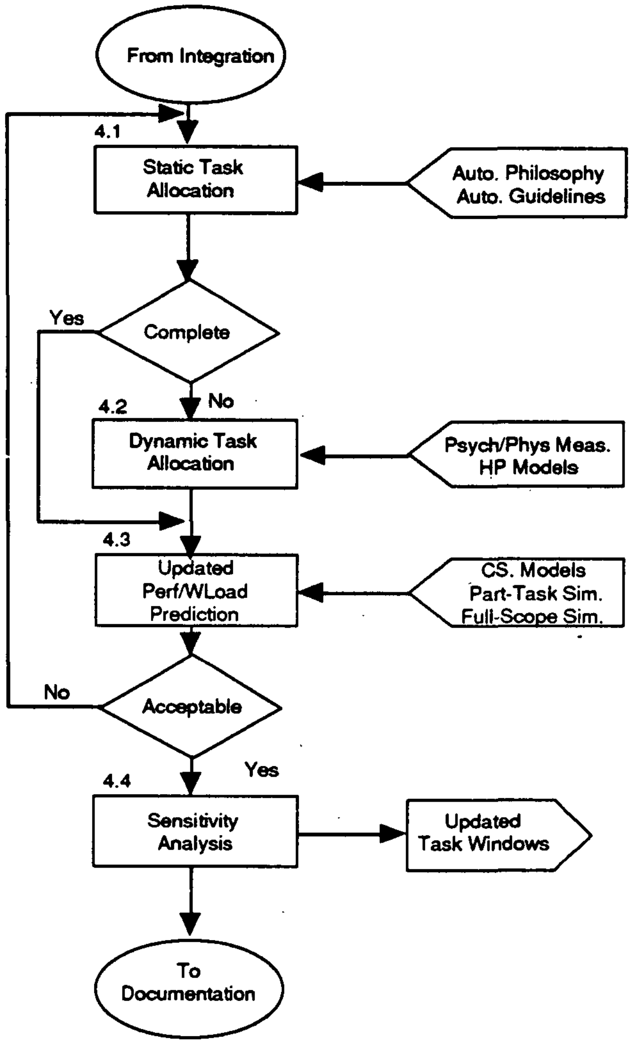


FIGURE 22. FINAL DESIGN

Tasks that could clearly be performed acceptably by either humans or automation (i.e., "H/A") are considered for dynamic or time-varying allocation. Approaches to determining when to shift the allocation (i.e., "H" to "A", and vice-versa) and which participant (H or A) initiates the allocation, are first explored. Note in general that dynamic allocation solutions will add monitoring and decision tasks to the participant who initiates the allocation in real time. If a feasible approach is identified, issues associated with human-computer interaction, including how humans will monitor the performance of those tasks that are dynamically allocated, are then addressed.

A variety of detailed design issues are resolved at this point. One of the most important issues concerns how humans will monitor the performance of those tasks that are automated. Crew system layout, arrangement, etc., are also finalized.

Evaluation during this phase requires much more elaborate methods than in prior phases. This is due both to the comprehensive nature of the design at this point and to the need for definitive information to assess achievement of design objectives. Thus, total crew system models, part-task and full-system simulations are now essential tools.

Summary

This section has presented a set of procedures for allocating system functions within the overall process of design. It has been argued that patterns of allocation-design-evaluation occur repeatedly throughout design, making it difficult to isolate one particular step as "allocation." Furthermore, although the flow chart presentation may give the impression that allocation decisions can be converted to procedures to the point of removing designer judgment, it should be emphasized that we believe these decisions can be enhanced with proper support, but cannot be replaced.

Information and Computational Support Requirements

The function allocator, whether using the present methodology or not, requires a wide variety of input information and produces a sizable body of output. Table V summarizes these requirements along with the types of supports and tools for accessing, generating and managing them per step of the allocation methodology. The figure contains five panels, one panel per major phase of the process. Step numbers and names match those in the procedural flowcharts that were presented above (Figures 18, 20-22).

Inputs—Scanning the "Input" column of Table V reveals a long list of archival sources and intermediate results that the allocator would use in the methodology. These inputs include mission requirements, soft and hard constraints on the eventual design solution, guidelines, past systems with potentially workable design elements, industry and government standards, and so on. For the present methodology, which emphasizes iteration of the allocation-design-evaluation cycle, inputs also include tentative allocation decisions, intermediate design solutions, clusters of potentially complementary and competing tasks, and performance predictions.

Outputs—The allocator also generates several intermediate and final outputs shown in the "Output" column of Table V. His or her primary output is, of course, the design specification. In our characterization that focuses on the human-system interaction, the design specification and "task window" are one and the same. As Figure 17 suggested, it contains a verbal task description, display characteristics (medium, location, size, symbols, font, dynamic elements, etc.) in verbal and graphic forms, control characteristics (medium, location, etc.) also in verbal and graphic forms, and operating procedures for normal and abnormal conditions. Display and control information would be produced from CAD software.

TABLE V — INFORMATION, SUPPORTS, AND TOOLS FOR THE FUNCTION ALLOCATION METHODOLOGY

REQUIREMENTS DEFINITION

#	STEP	INPUTS	OUTPUTS	SUPPORTS/TOOLS
1.1	Mission description	Specifications Standards Performance & cost goals	Text and graphic description of representative scenario	Information retrieval Archival databases
1.2	Define baseline system	Specifications Past designs Standards	Text and graphic description of baseline system	Information retrieval Archival databases
1.3	Construct nominal timeline	Representative scenario Baseline system description	System state timeline	Flight performance data System and subsystem models Database construction Information retrieval
1.4	Build function timeline	System state timeline	Function timeline	Function dictionary Function decomposition tool Information retrieval Database construction
1.5	Define baseline allocation	Past designs Baseline system description	Allocation timeline	Archival database Information retrieval Database construction
1.6	Develop baseline design	Past designs Baseline system description	Baseline task descriptions Baseline displays, controls and procedures	Archival database Design tools Human engineering design tools Information retrieval Database construction

TABLE V — (Continued)

INITIAL DESIGN

#	STEP	INPUTS	OUTPUTS	SUPPORTS/TOOLS
2.1	Sort functions	Function timeline	Functional requirements dbase	Sorting utilities
2.2	Initial allocation	Function requirements dbase Baseline allocation Automation philosophy	Allocation timeline	Information retrieval Automation guidelines Database construction
2.3	Initial task design	Functions allocated to H or H/A Baseline task descriptions Baseline displays, controls, and procedures	Task descriptions Displays, controls, procedures	Function decomposition tools Design guidelines Design tools Human engineering design
tools				Information retrieval Database construction
2.4	Performance prediction	Task descriptions Displays, controls, procedures Allocation timeline	Performance predictions Workload predictions	Human performance data Human performance models Information retrieval Database construction Schedule computation Data visualization tools
2.5	Sensitivity analysis	Functional requirements dbase Allocation timeline	Allocation timeline	Data transformation tools Data visualization tools

TABLE V — (Continued)

DESIGN INTEGRATION - COMPLEMENTARY TASKS

#	STEP	INPUTS	OUTPUTS	SUPPORTS/TOOLS
3.1	Construct relationship network	Functional requirements dbase Task descriptions Displays, controls, procedures	Relationship database Pairwise ratings	Sorting utilities Rating tools Composite rating definitions Database construction
3.2	Initial cluster analysis	Relationship network Task descriptions Displays, controls, procedures	Task clusters of potentially complementary tasks	Clustering algorithms Database construction Data visualization
3.3	Integrated task design	Designated clusters of potentially complementary tasks Task descriptions	Updated task description Updated displays, controls, and procedures	Design guidelines Design tools Human engineering design
tools				
		Displays, controls, procedures		
3.4	Performance prediction	Updated task descriptions Displays, controls, procedures	Performance predictions Workload predictions	Human performance data Human performance models Workload rating methods Mockups Part-task simulators
3.5	Sensitivity analysis	(Same as 2.5)	(Same as 2.5)	(Same as 2.5)

TABLE V — (Continued)

DESIGN INTEGRATION - COMPETING TASKS

#	STEP	INPUTS	OUTPUTS	SUPPORTS/TOOLS
3.6	Update relationship network	Initial relationship network Function requirements dbase Performance predictions Task descriptions Displays, controls, procedures	Updated relationship network	Sorting utilities Rating tools Composite ratings schemes Information retrieval Database construction
3.7	Update cluster analysis	Relationship network Task descriptions Displays, controls, proc Function timeline Function requirements dbase	Task clusters of potentially competing tasks	Clustering algorithms
3.8	Separated task design	Designated clusters of competing tasks Task descriptions	Updated task descriptions Updated displays, controls, proc Updated allocation timeline	Design guidelines Design tools Human engineering design
tools		Displays, controls, procedures Allocation timeline		
3.9	Performance prediction	(Same as 3.4)	(Same as 3.4)	(Same as 3.4)
3.10	Sensitivity analysis	(Same as 2.5)	(Same as 2.5)	(Same as 2.5)

TABLE V — (Continued)

FINAL DESIGN

#	STEP	INPUTS	OUTPUTS	SUPPORTS/TOOLS
4.1	Static task allocation	Functional requirements dbase Allocation timeline Performance predictions Workload predictions Task descriptions Displays, controls, procedures Automation philosophy	Updated task descriptions Updated displays, controls, proc Updated allocation timeline	Sorting utilities Human engineering design tools Training/aiding design tools
4.2	Dynamic task allocation	(Same as 4.1)	(Same as 4.1)	(Same as 4.1)
4.3	Performance prediction	Task descriptions Displays, controls, procedures Allocation timeline	(Same as 3.4)	Crew station models Mockups Part-task simulator Full-mission simulator
4.4	Sensitivity analysis	(Same as 2.5)	(Same as 2.5)	(Same as 2.5)

In addition, each task window contains a model (computational, logical or empirical) of the task and performance predictions based on the model. Models may be represented as equations or software programs, written in languages such as SAINT (ref. 7) or STELLA.* The outputs of these models would be portrayed graphically or numerically.

Enroute to the final design specifications, the allocator also produces design requirements, various timelines (mission, function and allocation), function descriptions, intermediate task windows, and evaluation data regarding the viability of the allocation scheme and design solution in practice.

Supports and Tools—The right-most column of Table V lists the types of procedural and computational support needed for accessing the inputs, generating the intermediate and final outputs, and performing the transformations from one to the other. General supports such as database operations and information retrieval are included along with more specialized aids such as design tools (CAD), human engineering design tools (e.g., COMBIMAN, ref. 9), and cluster analysis methods.

A Key Analogy—It is useful to consider these supports in terms of the following analogy. The function allocation problem in system design bears a number of similarities to the allocation problem in large-scale program management. Both the system designer and the manager define, or are given, goals and must determine the functional requirements for achieving these goals. Given functions and a budget, they then must dole the functions among a set of competent resources.

In both domains, the goal is to produce an allocation scheme that services all demands on time and to desired performance levels. Furthermore, the scheme should load each resource used to a tolerable level across time. In addition to being effective, the allocation scheme should be efficient. That is, it should request only the resources needed and no more, thereby remaining within budget. The budget is usually a financial one in the case of the program manager. For aircraft designers, there are several budgets—financial; aircraft weight and size; personnel budget at the macro level of operations; human information processing resources at the micro-level, etc.

In program management and system design alike, some key challenges in the allocation process are to:

- Define work demands (functions) and resources in transferable terms so that demands can be readily mapped to "demand satisfiers." For example, in program management, demand satisfiers are usually knowledge and skills types required to fulfill task demands. In design, demand satisfiers are sensing, processing and execution resources whether provided by a human or a machine.

- Estimate the amount of a resource needed to satisfy some demand. Allocation schemes typically assume that a competent resource is available and that "amount of resource required" is some time-related metric (e.g., 2 person-weeks of a programmer; two seconds of visual attention). "Load" is then defined as the ratio between time required and time available.

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* Available from High Performance Systems, Inc., 13 Dartmouth College Highway, Lyme, NH 03768

- Given definitions of work demands, deadlines, and available resources, schedule the resources to demands and calculate performance metrics (e.g., percentage of demands accomplished over time, percentage of resources spent, task queues, "deliverables" met or missed, the critical path, load per resource, slack times, etc.).

- Keep an enormous amount of data organized, represent the scheduling problem, perform the calculations, view the results, and modify the allocation based on feedback.

- Shift back and forth among various views of the same data. For program management, particularly useful views of the data include Gantt charts (i.e., functions by their duration plotted on a timeline), PERT networks (dependency diagrams), PERT plotted on a time scale, and the hierarchical relationships among tasks independent of time (graphical work breakdown structure).

The major difference between the manager and the system designer is in anticipatory requirements. Following program design, the manager typically executes his or her own allocation scheme as the program unfolds. Therefore, when performance, workload or resource expenditures begin to deviate from planned levels, the manager can adjust the allocation scheme to recover. This is a closed-loop control problem.

In contrast, the system designer's allocation scheme must be more nearly "right" at the end of design time because the designer will not be able to correct its flaws in real time. The designer hands off the allocation scheme to a different party for implementation (i.e., manufacturing and the end-user). Therefore, since he or she cannot fix matters in real time, the designer is left to anticipate and design for all eventualities in open-loop form. The extensive engineering change proposal (ECP) process that follows most complex system design efforts testifies that our ability to perform the allocation task in open-loop form is limited.

The point of comparing system design and program management is that, where they are similar, concepts and supports from one domain are likely to be useful in the other. More specifically, several existing computer-based program management tools (e.g., Symantec Timeline 3.0) provide database, computational, and data viewing functions that are called out in Table V for system design.

Program management tools help users to solve allocation and scheduling problems. The user typically starts by defining the necessary tasks to achieve program goals and then determines task resources requirements. Tasks are then scheduled relative to milestones and one another (dependencies are set). Given these inputs, the tools help to compute the timelines of expected work and expected resource expenditures over time, to locate and measure slack time, etc. In addition, most packages display the program plan and allocation scheme in a variety of formats including tables and plots, Gantt and PERT charts. The need for similar functions in system design should be apparent.

Program management tools also help users simply to organize and manage the enormous volume of data required to make allocation decisions in large-scale program management efforts. Similar support is needed in crew system design where the allocator must keep track of timelines and their variations, computations performed on the timelines, task descriptions and task data, the allocation, etc.

In sum, these tools support many of the operations of our allocation methodology. They help users to construct and then sort a database of tasks along any of several dimensions (e.g., by time, by function, by resource, by dependency, etc.). They also permit the user to update task data (e.g., expected duration), propagate the new task data throughout the timeline, and, thereby, determine a new resource demand profile, "critical path," etc.

What do human-machine system designers need that program management tools do not deliver? Two additional needs are most apparent: (1) task design tools; and (2) a means to estimate performance, workload, training requirements, equipment costs, etc., for tasks that are typically assigned to the human crew.

Therefore, to support function allocation in system design, the functionality of project management tools would have to be augmented with ways to create the information found in "task windows" (i.e., specific displays, controls and procedures), and with ways to estimate task attributes (performance, workload, etc.).

The first of these needs can be met with CAD and biomechanical CAD systems. The second can be met with modeling capabilities, either computational or empirical, that can generate estimates of system and human performance in closed-loop form. This capability allows the designer to "play" his allocation under several scenario variations by simply manipulating the stochastic elements associated with task performance, external events, etc. In other words, the allocation process involves scheduling demands to resources across time according to a *nominal* timeline. To test the allocation under alternative demand schedules, one needs the power of simulation.

After these two classes of information are generated, task performance estimates can be shipped to the schedule computational engine. This capability helps the human allocator to update the timeline, assess the distribution of resource demands, and compute system-level performance metrics such as slack time and critical path.

Support System Architecture

Based on this analysis (and image) of the allocator's needs, we sought to define the functionality of an integrated support system. To accomplish this, we first extracted the unique information and support items from Table V and then grouped the items into classes of like purpose. Table VI shows the results of this exercise.

The left-hand column of this figure lists the various data that are generated and used over the course of the methodology. They have been grouped into six classes:

1. ***Timelines*** (see Table III) are of three varieties. The system state timeline captures the vehicle and subsystems states in snapshot form, one record per interval, over the mission periods of interest. The function timeline simply adds to this basic system state timeline, information fields that define the functions that must be performed during each interval to cause the next desired state. Finally, the allocation timeline (see Table IV) adds to the system state and function timeline the performer to which each function is assigned.

TABLE VI— INFORMATION AND SUPPORT REQUIREMENTS GROUPED BY SUPPORT CATEGORY

INPUTS AND OUTPUTS

TIMELINES
- Allocation timeline
- Function timeline
- System state timeline
- Updated allocation timeline

FUNCTION REQUIREMENTS
- Baseline allocation
- Function descriptions
- Text and graphic description of baseline system
- Text and graphic description of representative scenario

PERFORMANCE & COST GOALS
- Performance & cost goals

TASKS WINDOWS
- Displays, controls, procedures
- Updated displays, controls, procedures
- Task descriptions
- Updated task descriptions

FUNCTION RELATIONSHIPS
- Pairwise ratings of functions
- Designated clusters of potentially competing tasks
- Designated clusters of potentially complementary tasks
- Relationship database
- Relationship network
- Updated relationship network
- Task clusters of potentially competing tasks
- Task clusters of potentially complementary tasks

EVALUATION DATA
- Performance predictions
- Specifications
- Standards
- Workload predictions

SUPPORTS AND TOOLS

SUPPORT SYSTEM FUNCTIONS

- File Management
- Database Construction
  - Database construction tools
  - Function decomposition tool
  - Sorting and searching utilities
- Computation & Analysis
  - Clustering algorithms
  - Composite rating schemes
  - Data transformation tools
  - Schedule computation
- Viewers
  - Data visualization tools
- Browsing & Retrieval
  - Information retrieval

ARCHIVES

- Databases
  - Allocation methodology steps
  - Automation guidelines
  - Design guidelines
  - Flight performance data
  - Function dictionary
  - Human performance data
  - Past designs
  - Specifications
  - Standards
- Tools
  - Crew station models
  - Data comparison tools (statistics)
  - Design tools
  - Full-mission simulator
  - Human engineering design tools
  - Human performance models
  - Mockups
  - Part-task simulators
  - Rating tools
  - System and subsystem models
  - Training/aiding design tools

2. ***Function requirements*** refer to the attributes that define each function such as identification, type (e.g., management of aircraft movement), duration, earliest start time, latest start time, parent functions, criticality, etc.

3. ***Performance and cost goals*** are derived from system specifications and represent the standards against which all design alternatives are eventually judged.

4. ***Task windows*** refer to a collection of data fields that describe a particular mechanization of some function for a human crew member.

5. ***Function relationships*** refer to all pairwise combinations of functions that are potentially performed by the human crew. Information about each pair of functions includes the extent to which they share similar goals (i.e., parent function), subsystems, information and temporal slots. In addition, once converted to tasks, the extent to which tasks share human information processing resources is included in this category.

6. ***Evaluation data*** emerge from two places: external sources that drive the design process (e.g., size and weight, human performance requirements, etc.) and from results of modeling and empirical studies. The latter are compared with the performance and cost goals to determine the degree to which the design satisfies the objectives.

The right-hand column of Table VI summarizes a set of five major support functions and two broad classes of tools that emerge from the allocator's task demands.

1. ***Basic file management*** support refers to needs for creating, storing and retrieving the results of the allocation work.

2. ***Database construction and manipulation tools*** are a pervasive need as the allocator builds the structures that contain the information in the left-hand column of Table VI. In addition, once constructed, the databases are sorted and searched in several of the allocation methodology steps.

3. ***Computation and analysis tools*** that are specific to the allocator's needs include clustering algorithms to support the identification of related functions, schemes for developing weights or ratings of function relationships, and a raft of relatively simple arithmetic and probability computations to help in schedule computations.

4. ***View s*** refers to alternative ways of portraying a set of information to the human analyst. For allocation problems in particular, these views include Gantt charts of functions by time, PERT networks, PERT networks by time, and network diagrams of nodes and arcs to depict function relationships.

   A particularly salient example of the viewer function can be seen in Table VII and in Figure 23. Table VII shows a (partial) function relationship database (the specification for which can be found in Appendix I). Each row represents a pair of functions that could be assigned to the human crew

member. Columns represent relationship types (e.g., goals, information, composite ratings of the user's own making, etc.). Figure 23 shows the results of accessing and examining this data file through a network viewer that has "filtering" capabilities. The lower two frames depict portions of the relationship network of all functions as they compare along the goals attribute. The higher the value on the arc, the stronger the nodes (functions) are related to the same goals. The lower left-hand network is shown in response to the allocator's desire to "show all" arcs; the lower right-hand network has been filtered to show only those relationships that exceed a rating of 0.5. This type of support takes advantage of the human allocator's pattern recognition abilities.

TABLE VII — FUNCTION RELATIONSHIPS DATABASE

Funct i	Funct j	Shared Goals	Shared Info	Shared Subsyst	Temporal Co-occur	Shared HIP res.	Composite $= R_G * R_I$
1	2	.8	.6	.1	.9	.8	.48
1	3	.2	--	.1	--	.1	--
1	4	--	.4	.9	.9	.6	--
1	5	--	--	--	.8	.7	--
1	6	.1	--	.8			.45
1	7	.5	.9	.9	.8	.5	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	--	.	.	.	.
2	3	.3		.5	.7	.2	--
2	4	.9	.9	.9	.9	.9	.81
2	5	--	.	.	.	.	.
2	6	--	.	.	.	.	.
.		.			.		

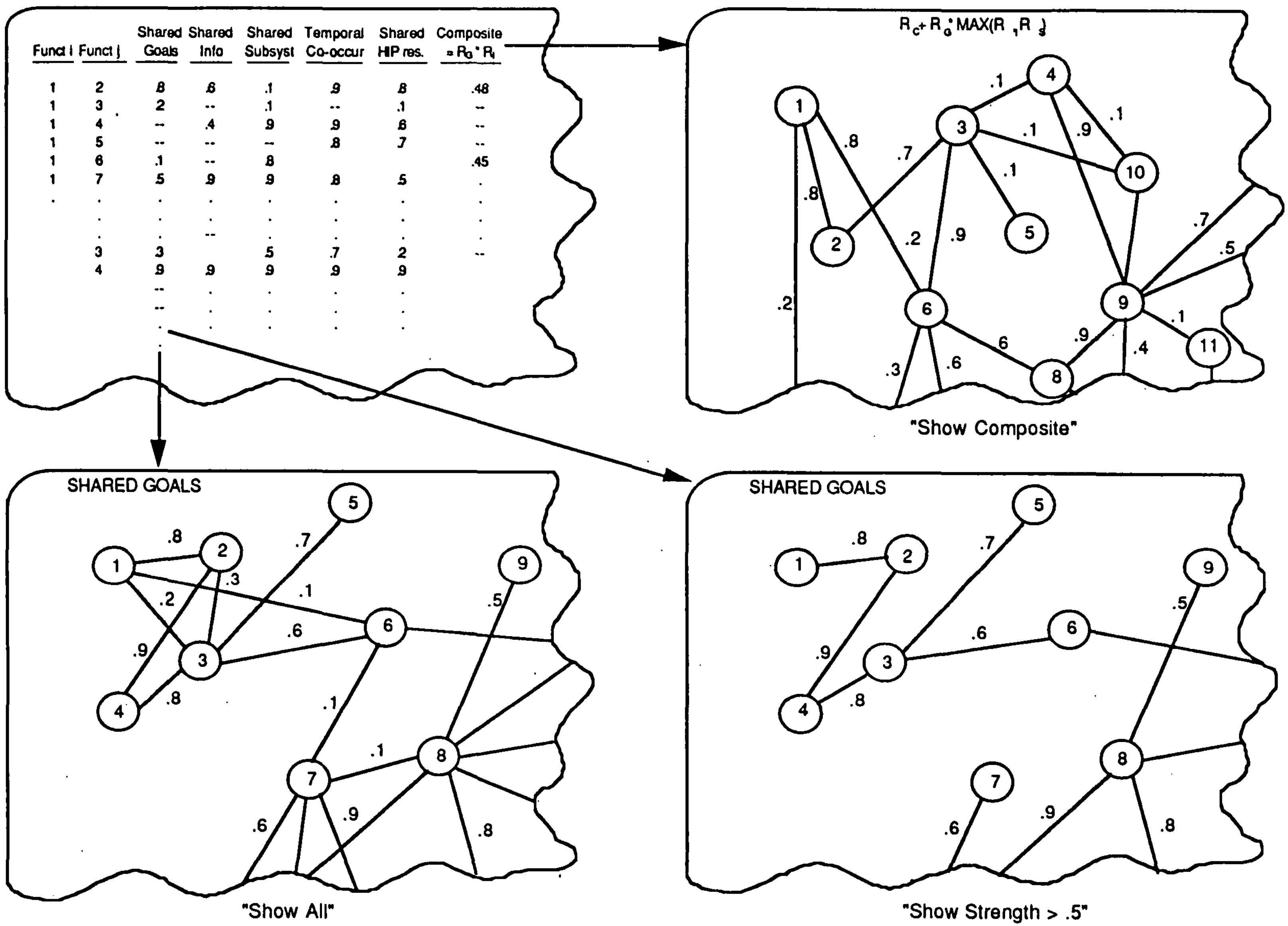

FIGURE 23. FUNCTION RELATIONSHIP VIEWING AND CLUSTERING

5. ***Browsing and retrieval*** are general support functions that are needed to locate information either from external sources and databases or from the program data (i.e., left-hand column).

   Additional supports of interest to the allocator include external databases and various speciality tools that are designed for relatively narrow information needs. These are summarized in the lower half of the right-hand column in Table VI.

   Figure 24 depicts a software architecture that can provide the support functionality, the data repository for program information, and access to external databases and speciality tools. As a start at a much more detailed specification of this environment, Appendices I and K define the program database fields.

Example of the Methodology and Support System

With the methodology and support system now described in general terms, it is appropriate to examine how they would be applied to arrive at allocation decisions in practice. To do this requires a detailed look at the specifics of a commercial flight mission, and consideration of mission events, a function timeline, function characteristics, and the iterations among allocation, design and evaluation to arrive at final allocation decisions.

We used the LAX to JFK commercial flight, that was defined in some detail previously, as a representative mission. Also for purposes of demonstrating the methodology, we worked with only a portion of the total mission, the "liftoff" segment of the takeoff phase. Using vehicle dynamics and takeoff conditions for a typical commercial transport, this segment lasts less than one minute. Nevertheless, the system and crew are required to perform a large number of functions during the liftoff segment (see Figure 10).

In this description, the map between the steps in the methodology (see Table V) and steps in the example is as follows:

Methodology Phase	**Steps in Example**
Requirements Definition	1 through 7
Initial Design	8 through 15
Design Integration - Complementary	16 through 23
Design Integration - Competing	24 through 30
Final Design	31 through 38

The designer begins the process with an empty "Program Database" (see Figure 24) and proceeds to fill in the information that describes the allocation scheme. To accomplish this, the designer accesses information from external sources, develops alternative allocation schemes, designs task windows, and evaluates these designs through analytical and empirical means. As the designer proceeds through the methodology, the program database is used to store intermediate results that support the allocation, design and evaluation steps. As a result, data in several fields are updated a number of times. When the methodology has been completed, the program database contains the key design information: task windows and an allocation timeline.

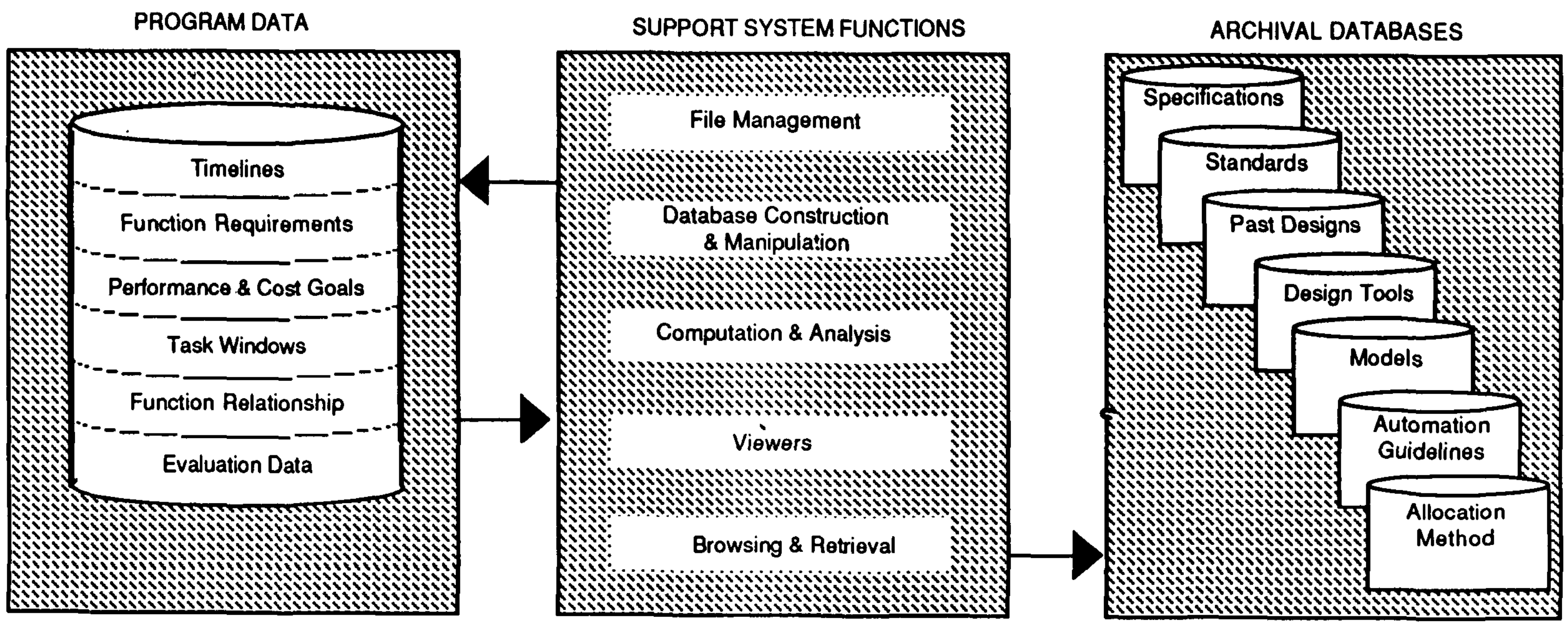

FIGURE 24. ARCHITECTURE FOR FUNCTION ALLOCATION SUPPORT SYSTEM

A Fictional Design Example.

For purposes of illustration, consider the following fictional account of an upgrade to an existing commercial transport aircraft.

The aerodynamics analysis team of a particular commercial transport has determined that energy efficiency could be increased by a small, but significant, margin if flight control better reflected prevailing environmental conditions. Their fuel price projections suggest that the estimated margin could save airline companies several million dollars annually. As it turns out, the team's analysis also shows that potential fuel savings would be greatest during transition segments of flight, such as liftoff and climb where fuel burn rates tend to be greatest.

In its analysis, the aerodynamics team shows that energy efficiency can be increased if drag associated with flap angle can be adjusted continuously rather than in discrete steps. Current operating procedures for normal takeoff and climb recommend decreasing flap angle in discrete steps from maximum deflection (20 degrees) at rotation velocity (VR) to "cleaned-up" (fully retracted) at V2+80 knots. For this particular aircraft, retraction steps are tied to airspeed according to the following recommended flap retraction schedule:

Airspeed (kts)	**Flap Position (degrees)**
V2+10	20 to 10
V2+20	1 to 5
V2+60	5 to 1
V2+80	1 to 0 (fully retracted)

In the current aircraft, flap retraction steps are initiated by the crew when they detect that airspeed has reached a target value. Flap position is controlled by positioning a lever arm to one of several fixed detents. Feedback on flap angle is provided to the crew by means of a panel instrument.

The challenge to the design team is to achieve the fuel savings by designing a means to control drag associated with flap position in a continuous manner. Several alternatives appear viable. At one extreme, flap position control might be fully automated. This would require extensive hardware and software development to be able to acquire vehicle and atmospheric state data in real time, compute "flap trim," and govern flap angle. At the other extreme, control might be given to the crew by presenting real time displays of energy use and flap position in any of several formats and providing continuous control of flap angle. This alternative would involve crew station alterations, new operating procedures, and possibly new training requirements. Several intermediate solutions that blend computer and human resources also appear conceivable.

1. ***Develop system requirements***—The crew system design team "accepts" the aero team's challenge and first develops a verbal definition of the design goal. Table VIII illustrates in outline form the spirit of their output.

TABLE VIII. SYSTEM GOAL AND REQUIREMENTS

Design Goal:	Increase energy efficiency in transition segments by 8%.
Mission Type:	Passenger and cargo transport

Operating conditions:	Weather
	   Full range
	   Variable across mission segments
	Temperature
	Day and night
	Altitude
	Traffic
	   Typical concentrations for 1990's
	Airfields
	   Facility descriptions and capabilities
	Regulatory agency operating procedures

System Requirements:	Production costs:
	   Design
	   Fabrication
	   Assembly
	   Test
	Operating costs:
	   Fuel
	   Manpower (crew complement)
	   Personnel
	   Training
	   Logistics
	System Performance
	   Passenger and Cargo Capacity
	   Size
	   Weight
	   Safety of Flight
	Crew System Constraints:
	   Volume
	   Use of existing aircraft systems
	   Use of existing equipment
	   Regulatory requirements

In general, we presume that system requirements emerge from customer needs, cost savings opportunities (as in the present fictional scenario), technological opportunities, etc. The requirements themselves are likely to be captured in a needs document that is a given to the design team to start the process. In analyzing these goals, the design team defines the full range of performance conditions and system-level criteria that must be met. In addition, the data help to size the system in terms of capacity, development costs, manufacturing requirements, etc. The design team's output is then captured in a more or less thick system requirements document.

2. ***Define baseline system***—For our example, the design team is upgrading a particular aircraft. Hence, vehicle dynamics, flight performance, subsystems and their performances, the crew station, system production, operating costs, etc. (See Table VIII) will be derived from the particular aircraft.

3. ***Construct nominal system state timeline***—Accessing a vehicle dynamics model for the particular aircraft from the archived model base, the design team produces a nominal mission state timeline and stores it into the "Timelines" sector of the program database. Table IX depicts a piece of what such a timeline would contain. Appendix J describes the recommended structure and data fields for the complete program database of which the nominal state timeline is a component.

   Each record of the timeline represents a snapshot of the state of the vehicle and its environment. Table IX shows the values for only seven parameters—elapsed time, airspeed, X and Y positions in nautical miles relative to the pre-ground roll point on the runway, altitude, flight path angle (gamma), and heading. These parameters are displayed at a five-second update rate. These values were produced with a rudimentary point mass vehicle dynamics model written in a microprocesssor-based spreadsheet program, (i.e., Excel). For the illustration, only seven minutes of the mission are shown, starting the clock when the takeoff ground roll begins. This period covers the ground roll, liftoff and a portion of the climb segment of the mission. The "liftoff" segment begins when the aircraft achieves rotation velocity (i.e., VR = 163 kts for this example) and ends when it passes through 50 feet AGL.

   Clearly, more sophisticated aerodynamic models are available that generate values for these parameters as well as the entire vehicle state vector, and at any level of granularity desired. The five-second increment was selected strictly for illustrative purposes. Furthermore, although not shown in Table IX, nominal subsystem states, (e.g., flaps setting) and the relationships between the system and external objects, such as other aircraft and ground points, also would be represented in the total system state timeline.

TABLE IX. EXAMPLE OF SYSTEM TIMELINE

No.	Segment	Time	kts	Xnm	Ynm	alt	gam	Hdg
1	Position hold	0:00:00	—	—	—	—	—	—
2	Position hold	0:00:00	—	—	—	—	—	—
3	Position hold	0:00:00	—	—	—	—	—	—
4	Ground roll	0:00:00	0	0.0	0.0	0	0	90
5	Ground roll	0:00:05	9	0.0	0.0	0	0	90
6	Ground roll	0:00:10	21	0.0	0.0	0	0	90
7	Ground roll	0:00:15	36	0.0	0.0	0	0	90
8	Ground roll	0:00:20	53	0.1	0.0	0	0	90
9	Ground roll	0:00:25	71	0.2	0.0	0	0	90
10	Ground roll	0:00:30	89	0.3	0.0	0	0	90
11	Ground roll	0:00:35	107	0.4	0.0	0	0	90
12	Ground roll	0:00:40	127	0.5	0.0	0	0	90
13	Ground roll	0:00:45	148	0.7	0.0	0	0	90
14	Liftoff	0:00:50	166	0.9	0.0	0	2	90
15	Liftoff	0:00:55	184	1.1	0.0	21	7	90
16	Liftoff	0:01:00	198	1.4	0.0	46	12	90
17	Liftoff	0:01:05	201	1.7	0.0	74	17	90
18	Initial ascent	0:01:10	203	2.0	0.0	105	22	90
19	Initial ascent	0:01:15	204	2.2	0.0	141	25	90
20	Initial ascent	0:01:20	206	2.5	0.0	182	30	90
21	Initial ascent	0:01:25	207	2.8	0.0	232	30	90
22	Initial ascent	0:01:30	209	3.1	0.0	295	30	90
23	Initial ascent	0:01:35	210	3.4	0.0	378	30	90
24	Initial ascent	0:01:40	212	3.7	0.0	503	30	90
25	Initial ascent	0:01:45	213	4.0	0.0	628	30	90
26	Initial ascent	0:01:50	215	4.3	0.0	753	30	90
27	Initial ascent	0:01:55	216	4.6	0.0	1003	30	90
28	Initial ascent	0:02:00	218	4.9	0.0	1253	30	90
29	Initial ascent	0:02:05	219	5.2	0.0	1503	30	90
30	Trans/accel	0:02:10	221	5.5	0.0	1753	30	90
31	Trans/accel	0:02:15	222	5.8	0.0	2003	30	90
32	Trans/accel	0:02:20	224	6.1	0.0	2253	30	90
33	Trans/accel	0:02:25	225	6.4	0.0	2503	30	90
34	Trans/accel	0:02:30	227	6.7	0.0	2753	30	90
35	Trans/accel	0:02:35	228	7.0	0.0	3003	30	90
36	Trans/accel	0:02:40	230	7.3	0.0	3253	30	90
37	Trans/accel	0:02:45	233	7.7	0.0	3503	30	90
38	Trans/accel	0:02:50	236	8.0	0.0	3753	30	90
39	Trans/accel	0:02:55	238	8.3	0.0	4003	30	90
40	Trans/accel	0:03:00	241	8.6	0.0	4253	30	90
41	Trans/accel	0:03:05	244	9.0	0.0	4503	30	90
42	Trans/accel	0:03:10	247	9.3	0.0	4753	30	90
43	Trans/accel	0:03:15	250	9.7	0.0	5003	30	90
44	Trans/accel	0:03:20	253	10.0	0.0	5253	30	90
45	Trans/accel	0:03:25	256	10.4	0.0	5503	30	90
46	Ascent to 10K	0:03:30	259	10.7	0.0	5753	30	90

This timeline serves several needs:

- Defines the conditions under which system functions will have to be performed. Conditions that affect human performance (e.g., barometric pressure, illumination, attitude with respect to gravity, etc.) are of particular interest to the methodology.

- As a nominal timeline, characterizes the expected behavior of the system. Therefore, each snapshot can be thought of as a new milestone to be achieved. System and subsystem state changes that effect each new state constitute the functional requirements that the design team must meet.

- A nominal timeline, provides a benchmark against which to compare the performance of alternative designs.

4. ***Build function timeline***—The design team's next step is to attach functional requirements to each time period in the nominal system state timeline. Accessing the Function Dictionary (see Appendix K) from an archive as an aid, the team proceeds to construct and store a function timeline. Table X shows the entire structure for each function.

   Table XI shows a part of the resulting function timeline. The four five-second intervals that define liftoff have been decomposed into their constituent requirements. As can be seen, each function is defined by a number, action verb, and object of the action. This information was accessed from the Function Dictionary (Appendix K). We have also entered hypothetical values for task type (DIS = discrete; CON = continuous; INT = intermittent), expected duration in seconds, criticality (1 = high, 4 = low) and, finally, the allocation (H, A, or H/A). Although not shown in Table–XI, data fields that the design team must also fill in per function include required performance, parent function(s), subsystem(s) used, information required, and others (see Table X).

   As discussed above in the overall methodology, several methods could be used to produce the functions and attach them to time periods. For our example, we have assumed that the design team has created a hierarchical structure of functions and subfunctions for each time period.

   Clearly, the effort to produce the function timeline depends on two primary factors: (1) the granularity to which functions are decomposed, and (2) the time step in which the nominal timeline is expressed. Table XI illustrates a modest analysis effort for just the liftoff portion of the nominal timeline. As can be seen from comparing Tables IX and XI, at a five-second granularity of system state changes, the liftoff segment expands approximately twenty-fold when functions are attached per snapshot.

   For the present example in particular, the design team would identify when, during the mission, flaps control is required, and then change the task type from discrete (in the baseline system) to continuous (for the new design). In addition, if there were opportunities for governing energy use through flap control during periods other than the segments in which such control occurs in the baseline, the team would add the flaps control function to these additional time periods.

TABLE X. STRUCTURE OF A FUNCTION

Identification	
Number	Numeric identifier
Indentation Level	Used to indicate hierarchical level
Function Name	English identifier
Category	Management of ... a/c movement, flight plan, etc.
Function type	Continuous, intermittent, discrete
Attributes	
Expected duration	Seconds
Duration variance	Seconds
Earliest start	Time relative to a mission milestone
Latest start	Time relative to a mission milestone
Goal (parent function)	Identifier of next higher-level function(s)
Predecessor function(s)	Identifier of temporal predecessor(s)
Trigger condition(s)	Initiating system state
Ending condition(s)	Terminating system state
Uses subsystem(s)	Identifier of subsystem
Criticality to mission	Judgment expressed as a rating
Information requirements	
Variable name(s)	Variable name(s) from system state vector
Required accuracy	Value (e.g., + or - value%)
No. samples required	One, multiple, or continuous
Allocation	
Designated performer(s)	Resource to which the function is assigned

5. ***Define baseline allocation***—Given the function timeline, the next step is to define a baseline allocation. Table XI contains the results of this operation (initially, the allocation code associated with each function would be blank in the program database). At this stage of the process, the design team adopts the allocation for all functions from the baseline system except for flaps control. Flaps control is assigned to H/A since the final allocation will depend on performance, technological feasibility, etc.

TABLE XI — EXAMPLE FUNCTION TIMELINE

No.	Segment	Time	#	Verb	Object	Type	Durtn	Crticl	Alloc
10	Ground roll	0:00:45	13	select	airspeed target	Dis	1.5	2	H
11	Ground roll	0:00:45	51	track	course	Con	—	2	H/A
12	Liftoff	0:00:50	122	monitor	comm message	Int	3.5	3	H
13	Liftoff	0:00:50	119	monitor	OW for obstacles	Int	8	1	H
14	Liftoff	0:00:50	121	callout	VR	Dis	4	2	H
15	Liftoff	0:00:50	108	monitor	subsystems status	Int	10	4	H
16	Liftoff	0:00:50	23	hold	heading	Con	—	2	H/A
17	Liftoff	0:00:50	22	monitor	heading	Int	2	2	H/A
18	Liftoff	0:00:50	2	adjust	roll	Con	—	1	H/A
19	Liftoff	0:00:50	3	adjust	yaw	Con	—	3	H/A
20	Liftoff	0:00:50	30	execute	climb	Int	sum	1	H/A
21	Liftoff	0:00:50	37	execute	pitch-up	Int	sum	1	H/A
22	Liftoff	0:00:50	1	adjust	pitch	Con	—	1	H/A
23	Liftoff	0:00:50	4	adjust	thrust	Con	—	1	H/A
24	Liftoff	0:00:50	26	monitor	flight path angle	Int	2	2	H/A
25	Liftoff	0:00:50	14	monitor	airspeed	Int	2	2	H/A
26	Liftoff	0:00:50	18	monitor	altitude	Int	2	2	H/A
27	Liftoff	0:00:50	25	select	flight path angle target	Dis	1.5	2	H
28	Liftoff	0:00:50	28	change	flight path angle	Con	—	2	H
29	Liftoff	0:00:50	17	select	altitude target	Dis	1.5	2	H
30	Liftoff	0:00:50	13	select	airspeed target	Dis	1.5	2	H
31	Liftoff	0:00:50	51	track	course	Con	—	3	H/A
32	Liftoff	0:00:50	22	monitor	heading	Int	2	2	H/A
33	Liftoff	0:00:55	122	monitor	comm message	Int	3.5	3	H
34	Liftoff	0:00:55	119	monitor	OW for obstacles	Int	8	1	H
35	Liftoff	0:00:55	121	callout	50 ft	Dis	4	2	H
36	Liftoff	0:00:55	121	callout	V2	Dis	4	3	H
37	Liftoff	0:00:55	126	request	gears up	Dis	4	3	H
38	Liftoff	0:00:55	128	request	spoilers off	Dis	4	3	H
39	Liftoff	0:00:55	107	monitor	flaps position	Int	2.5	2	H
40	Liftoff	0:00:55	76	select	landing gear-main up	Dis	3	2	H
41	Liftoff	0:00:55	77	select	landing gear-center up	Dis	3	2	H
42	Liftoff	0:00:55	78	select	landing gear-nose up	Dis	3	2	H
43	Liftoff	0:00:55	10	select	spoilers off	Dis	3	2	H
44	Liftoff	0:00:55	108	monitor	subsystems status	Int	10	4	H
45	Liftoff	0:00:55	23	hold	heading	Con	—	2	H/A
46	Liftoff	0:00:55	22	monitor	heading	Int	2	2	H/A
47	Liftoff	0:00:55	28	change	flight path angle	Con	—	2	H
48	Liftoff	0:00:55	1	adjust	pitch	Con	—	1	H/A
49	Liftoff	0:00:55	2	adjust	roll	Con	—	1	H/A
50	Liftoff	0:00:55	3	adjust	yaw	Con	—	3	H/A
51	Liftoff	0:00:55	4	adjust	thrust	Con	—	1	H/A
52	Liftoff	0:00:55	26	monitor	flight path angle	Int	2	2	H/A
53	Liftoff	0:00:55	14	monitor	airspeed	Int	2	2	H/A
54	Liftoff	0:00:55	18	monitor	altitude	Int	2	2	H/A
55	Liftoff	0:00:55	25	select	flight path angle target	Dis	1.5	2	H

TABLE XI — (Continued)

No.	Segment	Time	#	Verb	Object	Type	Durtn	Crticl	Alloc
56	Liftoff	0:00:55	17	select	altitude target	Dis	1.5	2	H
57	Liftoff	0:00:55	13	select	airspeed target	Dis	1.5	2	H
58	Liftoff	0:00:55	51	track	course	Con	—	3	H/A
59	Liftoff	0:00:55	22	monitor	heading	Int	2	2	H/A
60	Liftoff	0:01:00	122	monitor	comm message	Int	3.5	3	H
61	Liftoff	0:01:00	119	monitor	OW for obstacles	Int	8	1	H
62	Liftoff	0:01:00	108	monitor	subsystems status	Int	10	4	H
63	Liftoff	0:01:00	23	hold	heading	Con	—	2	H/A
64	Liftoff	0:01:00	22	monitor	heading	Int	2	2	H/A
65	Liftoff	0:01:00	28	change	flight path angle	Con	—	2	H
66	Liftoff	0:01:00	1	adjust	pitch	Con	—	1	H/A
67	Liftoff	0:01:00	2	adjust	roll	Con	—	1	H/A
68	Liftoff	0:01:00	3	adjust	yaw	Con	—	3	H/A
69	Liftoff	0:01:00	4	adjust	thrust	Con	—	1	H/A
70	Liftoff	0:01:00	26	monitor	flight path angle	Int	2	2	H/A
71	Liftoff	0:01:00	14	monitor	airspeed	Int	2	2	H/A
72	Liftoff	0:01:00	18	monitor	altitude	Int	2	2	H/A
73	Liftoff	0:01:00	25	select	flight path angle target	Dis	1.5	2	H
74	Liftoff	0:01:00	17	select	altitude target	Dis	1.5	2	H
75	Liftoff	0:01:00	13	select	airspeed target	Dis	1.5	2	H
76	Liftoff	0:01:00	51	track	course	Con	—	3	H/A
77	Liftoff	0:01:00	22	monitor	heading	Int	2	2	H/A
78	Liftoff	0:01:05	122	monitor	comm message	Int	3.5	3	H
79	Liftoff	0:01:05	119	monitor	OW for obstacles	Int	8	1	H
80	Liftoff	0:01:05	121	callout	V2+10	Dis	4	3	H
81	Liftoff	0:01:05	125	request	flaps 20 to 10	Dis	4	3	H
82	Liftoff	0:01:05	8	select	flaps 20 to 10	Dis	4	3	H
83	Liftoff	0:01:05	108	monitor	subsystems status	Int	10	4	H
84	Liftoff	0:01:05	23	hold	heading	Con	—	2	H/A
85	Liftoff	0:01:05	22	monitor	heading	Int	2	2	H/A
86	Liftoff	0:01:05	28	change	flight path angle	Con	—	2	H
87	Liftoff	0:01:05	1	adjust	pitch	Con	—	1	H/A
88	Liftoff	0:01:05	2	adjust	roll	Con	—	1	H/A
89	Liftoff	0:01:05	3	adjust	yaw	Con	—	3	H/A
90	Liftoff	0:01:05	4	adjust	thrust	Con	—	1	H/A
91	Liftoff	0:01:05	26	monitor	flight path angle	Int	2	2	H/A
92	Liftoff	0:01:05	14	monitor	airspeed	Int	2	2	H/A
93	Liftoff	0:01:05	18	monitor	altitude	Int	2	2	H/A
94	Liftoff	0:01:05	25	select	flight path angle target	Dis	1.5	2	H
95	Liftoff	0:01:05	17	select	altitude target	Dis	1.5	2	H
96	Liftoff	0:01:05	13	select	airspeed target	Dis	1.5	2	H
97	Liftoff	0:01:05	51	track	course	Con	—	3	H/A
98	Liftoff	0:01:05	22	monitor	heading	Int	2	2	H/A
99	Initial ascent	0:01:10	122	monitor	comm message	Int	3.5	3	H
100	Initial ascent	0:01:10	119	monitor	OW for obstacles	Int	8	1	H

6. ***Define baseline design***—As with the baseline allocation, the design team initially adopts the mechanization for all functions, except flaps control, from the baseline aircraft. This approach ensures that getting started is not an overwhelmingly arduous task. Along with the design information, the expected durations and duration variances are logged per function, based on performance data collected from the design and/or test activities associated with the baseline aircraft.

   For the example, we have assumed that design information is accessed from the archives of past designs, and in particular, from those associated with the baseline aircraft. This information is expressed as data flow diagrams, equipment interface protocols, signal flow diagrams, blueprints for structural components, equipment listings, drawings, software listings, photographs, data plots, descriptions of operating procedures, and so on. The team stores these sources directly (if in digital form) or pointers to them in the appropriate fields of the "task window" portion of the program database (see Appendix J).

   Of particular importance in this step is the identification of the human resources demanded by the baseline design. We have assumed that the human crew is characterized as a multiple resource processor composed of input, information processing, and output capabilities. Since the baseline design is largely adopted from an existing mechanization, the design team characterizes each task in terms of the input (visual versus auditory versus kinesthetic), information processing (verbal versus spatial), and output (manual versus speech) demands it places on the human crew. At this stage, merely identifying whether the resources are or are not demanded per function would suffice for computing the task schedule and resource demand profile in the next step.

7. ***Compute timeline metrics***—To summarize the state of the program database at this juncture, the team has developed a nominal system state timeline, the function requirements per time step, a preliminary allocation, and a preliminary task window (design). Before moving on to the heart of the allocation methodology, the team accesses a schedule computation tool and alternative viewers to examine the distribution of resource demands over time in the baseline allocation. Schedule computation refers to determining expected start and stop times per function along with the slack time associated with each. The team views these computations through a Gantt, PERT and/or PERT with time formats chart. In addition, tabulations of tasks by elapsed time, resource demands by elapsed time, and resource demands by task are computed and viewed.

   The purpose of this step in the methodology is to determine whether or not the preliminary allocation and task designs provide reasonably accurate performance estimates for the baseline system. This is an important determination given the comparative role of the baseline system in the next stages of the allocation methodology.

8. ***Sort timeline by function***—The first step in the initial design stage is to sort the function timeline by function. In our example, output from this step is shown in Table XII. As can be seen, repetitions of each function are grouped together, ordered by elapsed time. This view enables the design team to determine the range of conditions under which each function must be performed along with expected duration (based on the baseline design), information requirements, criticality, and the baseline allocation.

Of particular interest are functions associated with flaps control. The sorting operation shows the design team that continuous flaps control will be demanded during each time period of the liftoff segment. (Note: if a timeline for the entire mission were complete, the sorting operation would show all transition segments in which flap control was required, along with the operational conditions that surround this function.)

TABLE XII. EXAMPLE OF SORTED FUNCTION TIMELINE

No.	Segment	Time	#	Verb	Object	Type	Durtn	Crticl	Alloc
22	Liftoff	0:00:50	1	adjust	pitch	Con	—	1	H/A
48	Liftoff	0:00:55	1	adjust	pitch	Con	—	1	H/A
66	Liftoff	0:01:00	1	adjust	pitch	Con	—	1	H/A
87	Liftoff	0:01:05	1	adjust	pitch	Con	—	1	H/A
18	Liftoff	0:00:50	2	adjust	roll	Con	—	1	H/A
49	Liftoff	0:00:55	2	adjust	roll	Con	—	1	H/A
67	Liftoff	0:01:00	2	adjust	roll	Con	—	1	H/A
88	Liftoff	0:01:05	2	adjust	roll	Con	—	1	H/A
19	Liftoff	0:00:50	3	adjust	yaw	Con	—	3	H/A
50	Liftoff	0:00:55	3	adjust	yaw	Con	—	3	H/A
68	Liftoff	0:01:00	3	adjust	yaw	Con	—	3	H/A
89	Liftoff	0:01:05	3	adjust	yaw	Con	—	3	H/A
23	Liftoff	0:00:50	4	adjust	thrust	Con	—	1	H/A
51	Liftoff	0:00:55	4	adjust	thrust	Con	—	1	H/A
69	Liftoff	0:01:00	4	adjust	thrust	Con	—	1	H/A
90	Liftoff	0:01:05	4	adjust	thrust	Con	—	1	H/A
82	Liftoff	0:01:05	8	select	flaps 20 to 10	Dis	4	3	H
43	Liftoff	0:00:55	10	select	spoilers off	Dis	3	2	H
10	Ground roll	0:00:45	13	select	airspeed target	Dis	1.5	2	H
30	Liftoff	0:00:50	13	select	airspeed target	Dis	1.5	2	H
57	Liftoff	0:00:55	13	select	airspeed target	Dis	1.5	2	H
75	Liftoff	0:01:00	13	select	airspeed target	Dis	1.5	2	H
96	Liftoff	0:01:05	13	select	airspeed target	Dis	1.5	2	H
25	Liftoff	0:00:50	14	monitor	airspeed	Int	2	2	H/A
53	Liftoff	0:00:55	14	monitor	airspeed	Int	2	2	H/A
71	Liftoff	0:01:00	14	monitor	airspeed	Int	2	2	H/A
92	Liftoff	0:01:05	14	monitor	airspeed	Int	2	2	H/A

9. ***Allocate functions to H, A, and H/A***—The team initially allocates all flaps control functions to H, the human crew. This decision is based on an automation philosophy that defaults control to the human crew whenever the crew is capable of the task. However, at this stage, it is not clear to the team whether the human crew will be able to effect continuous control of flap position to meet energy efficiency performance goals because the precise mechanization for the associated functions has not been devised.

10. ***Produce initial designs for all H and H/A***—Initial task design for the flap control functions involves choosing displays, controls, and procedures. The design team tries several alternative designs. They converge on a concept for a CRT-based, Energy X Flaps Position display that shows current values of these system states relative to a computed optimal setting. Control is effected by a digital rocker switch that is integrated into the display. The design is developed from a CAD tool that is accessed from the tool archive, and the drawings and procedural details are logged into the Task Window portion of the program database.

11. ***Predict performance and fill-in task window***—The team then accesses a performance modeling language (e.g., STELLA) from the tools archive, and develops a human-system model of the energy control task. Data to estimate human input, processing and output parameters in the model are acquired from on-line sources such as the Engineering Data Compendium (ref. 10) and various human engineering handbooks that contain manual tracking performance information. Parameters for the system dynamics are adopted from the baseline aircraft, and various display/control orders are explored in a sensitivity analysis.

    The model is used to explore control accuracy measured in terms of RMS errors from desired flaps position for various display/control dynamics and in various mission time periods that exhibit more or less stringent control accuracy requirements (e.g., the liftoff segment requires better control performance than does the subsequent initial climb segment). As a result of the exercise, display characteristics are modified to increase the saliency of the offset between actual and desired Energy X Flaps values. These changes are logged into the flaps control task window in the program database.

12. ***Recalculate timeline metrics and locate resource overloads***—The task window information permits the design team to estimate the human resource requirements for the flaps control function across the different periods for which it is demanded. At this stage, estimates for input, processing and output resources are expressed in terms of percentages of total capacity available. Using these estimates, the team recomputes the resource demand profile and discovers that the new flaps control task has greatly increased the use of human visual inputs and spatial processing in the presence of other flight control, fuel control and flight plan management tasks during liftoff. Results from the schedule computation are used to update the program database. Furthermore, the potential conflict for human resources among the new flaps control task and other tasks is noted.

13. ***Attempt task scheduling to shift demands and recalculate***—The team sorts the function timeline by elapsed time and examines early start and late start times per function and the precedence relationships that involve flaps control. It appears that the opportunity to alleviate the conflict between the flaps

control and other contemporaneous demands cannot be accomplished in any simple manner through schedule adjustment. The key problem appears to be that several continuous tasks are demanded during liftoff and cannot be rescheduled in any simple manner.

14. ***Re-allocate as needed to achieve acceptable demand levels (H*, H/A* and H**)***—Based on the performance predictions and demand profile, the design team is forced to annotate several continuous control tasks in the H category with an asterisk (i.e., performance is marginal, and the allocation is, therefore, open to further exploration). The new piece of information uncovered in the analysis exercise is that several task allocations have been affected by the new flaps control task.

15. ***Update task windows for each reallocation***—To end this first pass through the methodology, the design team decides that further investment in polishing the design for the flaps control function in isolation is not warranted. Therefore, the team decides to move on to look for opportunities to reduce the human processing demands, especially during liftoff, by integrating the flaps control function with other functions.

16. ***Rate pairwise functions along goals, systems, and information***—The next design cycle begins with sorting the function timeline by elapsed time and allocation code to show all functions that have been assigned to H or to H/A. Further analyses and design then concentrate on these functions without concern for the "A" functions.

    The design team opens a new file in the program database that will hold all pairs of the H and H/A functions. Appendix J shows the fields within this section of the database. For all functions Fi and Fj, such that i is not equal to j, the design team rates the strength of each of several relationships between the functions in a pair. Relationships include the extent to which the functions share similar goals (defined in the program database as the similarity of the functions' parent functions), similar subsystems, and similar information requirements. In addition, composite ratings that capture logical and/or quantitative combinations of these three basic ratings are developed according to rules that the design team believes makes operational sense. The ratings are unlikely to reflect "truth" in any hard and fast manner. Rather, they capture the design team's experience and expertise, and therefore, reflect the qualitative character of all psychophysical judgments.

    Though qualitative, these judgments are valuable. They enable computer support of the very difficult design task of discovering relationships among distinct entities. By rating the pairwise relationships among functions, the design team provides the support system with sufficient information to create a relationship network of all H and H/A functions and to display the entire network or views into the network through various filters (e.g., "Show all relationships where shared goals ranked higher than x," or "Show all relationships where shared goals are greater than 0.5 but shared information requirements are less than 0.2"). Figures 23 and 24, discussed earlier, provide an image of this form of support.

17. ***Identify clusters of complementary tasks***—In addition to viewing the network directly, the design team submits the relationships data to a cluster analysis routine that identifies related functions through

mathematical analyses. This treatment augments the design team's visual pattern recognition capabilities for uncovering latent relationships.

From the network and cluster analyses the design team note that flaps control exhibits strong relationships along several dimensions with the control of pitch, pitch trim, roll, roll trim, thrust, and landing gear control as they all affect energy management. Flaps control also exhibits strong connections with control of thrust and flight path angle as they govern altitude and airspeed.

18. ***Combine task windows of related functions into integrated tasks***—On the basis of the cluster analysis, the design team retrieves the task windows for all the related functions. Opportunities for combining flaps control with attitude control seem unlikely. The team then hits on an integrated visual presentation of thrust control and flaps position control. Design tools (display CAD and biomechanical CAD tools) are accessed from the archive, and a preliminary design for the new integrated presentation and control are fashioned. The task windows for thrust and flaps control are effectively combined and the program database modified to reflect the change.

19. ***Update projections of task performance***—The team decides that another round of human performance modeling is necessary to estimate performance under all circumstances where the new integrated control task will be demanded. The display/control concept bears a resemblance to integrated flight directors, but the dynamics tend to be quite different. For this reason, not trusting the available human performance data on flight control with flight directors, the design team develops a laboratory prototype of the integrated thrust/flaps system, and collects empirical estimates of task performance independently of other demands.

    The results are very encouraging. RMS errors in maintaining both thrust and energy efficiency near optimal values are small. The team enters the performance estimates for the new task in the program database and proceeds to schedule computations.

20. ***Recalculate timeline metrics and locate resource overloads***—Using the schedule computation tools, the team discovers that, despite good performance on the new integrated task, overall demand for human visual processing resources remain unacceptably high during the liftoff segment.

21. ***Attempt task scheduling to shift demands and recalculate***—Attempts to reschedule the new task relative to other continuous tasks are not successful.

22. ***Re-allocate as needed to achieve acceptable demand levels (H*, H/A* and H**)***—No change.

23. ***Update task windows for each reallocation***—No change.

24. ***Rate pairwise functions on temporal and human IP resource competition***—Similar to step 16, the design team returns to the function relations part of the program database (Appendix J), looking for opportunities to separate new integrated task from its rivals for human resources. The team begins by sorting the function timeline by elapsed time to compute the frequency with which function pairs tend

to occur together in time. In addition, for functions that do tend to co-occur, ratings of the extent to which their task designs demand the same human information processing resources are entered. The design team bases their ratings on examination of the task windows for all functions that tend to co-occur.

25. ***Identify clusters of competing tasks***—Similar to step 17. By viewing the resulting network and applying cluster analyses to the ratings in search of competing tasks, the team finds that flaps control competes directly with flight control and monitoring the external scene for obstacles and other aircraft.

26. ***Attempt re-scheduling, modifying or transforming task windows of competing tasks***—The design team attempts unsuccessfully to change the competing tasks to ease human resource demands during liftoff.

27. ***Update projections of task performance per attempt***—No change.

28. ***Recalculate timeline metrics and locate resource overloads per attempt***—No change.

29. ***Re-allocate as needed to achieve acceptable demand levels (H*, H/A* and H**)*** —Having struck out on a static solution to the allocation problem, the team annotates the flaps control function as a double asterisk. Prospects of having to turn to an automation solution or to dynamic allocation appear strong.

30. ***Update task windows for each reallocation***—No change.

31. ***Review all H*, H/A* and H** allocations***—The team first revisits the automation question that they thought had been put to rest early on when they allocated the flaps control function to the human crew. Now, projections for hardware and software development requirements to automate the function are given serious consideration. The answers are not encouraging; an automatic solution will require development of expert system technology for flaps control under a wide variety of "exceptional cases." The original allocation to H or H/A stands.

32. ***Review all H/A to consider dynamic allocation***—The design team decides to view the problem as an opportunity for dynamic allocation. They have sufficient evidence to show that the human crew will be quite adept at the flaps control problem barring any serious competing demands from flight control. Therefore, in an unanticipated tack, the team decides to put allocation control into the hands of the human crew. They develop a scheme by which the crew can offload flight control (attitude and path control) to an automatic system whenever conditions appear favorable for enhancing energy efficiency through flaps control. Also, this design choice adds a new "H" task to the decomposition. The new task is the crew member's decision to retain or relinquish responsibility for flaps control.

    In effect, the team feels that automatic flight control technology is less of a technological risk than the flaps control technology. Moreover, they feel that the crew will be in the best position to judge in real time whether flight control can be set to automatic mode or not. To reflect this design decision, the

allocation field of the flight control function is updated to an H/A designation during the transition segments. Formerly, the function had been H only. The allocation code for flaps control remains at H.

33. ***Modify task windows of competing tasks***—The new dynamic allocation scheme requires that the flight and flaps control functions be "enabled" by the crew as needed and that the status of the automatic flight control system be portrayed to the human crew. Therefore, the team launches into another round of task design. They access the affected task windows and appropriate design tools and make the modifications.

34. ***Update projections of task performance***—Following these design changes, the new allocation scheme is examined in a series of low- to high-fidelity flight simulation tests. Resulting performance data are used to update task performance projections in the program database.

35. ***Recalculate timeline metrics and locate resource overloads***—Similar to step 20.

36. ***Attempt task scheduling to shift demands and recalculate***—Results show that task scheduling is not required.

37. ***Re-allocate as needed to achieve acceptable demand levels***—No change.

38. ***Update task windows for each reallocation***—Task windows for the flight control and flaps control functions are finalized. Specifications for the required hardware and software are then issued to the vendor community for bids.

Conclusions

This fictional account of the design team's progress through the function allocation methodology was intended to convey two images. First, it should be apparent that the methodology "dictates" very few operations. Rather, the emphasis is on supporting the design team's own experience, insights and judgments in reaching an acceptable allocation and design solution. Certainly, the methodology steps can be accessed as a form of assistance in addition to the support function, but the focus is on supporting judgments, not replacing or automating them.

Second, the example was also intended to show that our concept for an allocation support system is, in fact, a collection of well understood computer-based functions. Currently, these functions are provided in software tools for information retrieval, database management, project management support, electronic spreadsheets and data visualization.

Without question, the uncertainties associated with the support system concept center on the archived data sources as opposed to software functions. Our example depicts the design team accessing a wealth of relevant engineering and scientific data, tools, standards, etc., all through electronic means. Although recent initiatives, such as the DoD CALS (Computer Aided Logistics Support) program, are providing data standards and tools to capture and transmit design information in paperless forms, the majority of relevant archives may still reside

as paper. Examples of hard to access, but popular information, include the rationale for prior designs over and above the engineering drawings, inter-company design information, and scientific information expressed in design-usable forms. Moreover, the growth rates of these pertinent information bases continue to increase, making retrieval a progressively more difficult problem.

Ignoring the archived data problem for a moment, a rough implementation of the envisioned allocation support system is well within reach using current microprocesssor-based software. Initially, this implementation can be realized using separate software packages that are capable of importing and exporting files to effect data transfer. A more integrated product is clearly more desirable, but will require a significant software development effort.

In particular, Table XIII lists existing software applications that together could deliver the functionality in the Macintosh and PC environments. Question marks associated with data visualization reflect our uncertainty about the availability of software packages for both constructing and analyzing network representations. Such a tool would greatly support the need to explore function relationships. Finally, we note that the proposed support system (see Figure 24) could be delivered at relatively low cost using the separate software packages listed in Table XIII that could import and export data from one another. This near-term solution, however, would be a cumbersome one from the allocator's perspective. If the conceptual design for the allocation support system makes sense, the next logical steps are to design and develop an integrated version of the system.

TABLE XIII. EXISTING SOFTWARE PROGRAMS THAT DELIVER THE SUPPORT SYSTEM FUNCTIONS

Support Function	Macintosh	PC/DOS
File management	Macintosh toolbox	DOS
Database construction	*4th Dimension*	*dBase*
Scheduling	*MacProject* *Microplanner Plus*	*Timeline 3.0*
Data analysis	*Data Desk* *Systat* *Excel*	*Systat* *Lotus 1-23*
Data visualization	*MacProject* *Microplanner Plus*	*Timeline 3.0* *??*
Information browsing	Hypermedia Tools	Hypermedia Tools

Method B: Decision Rule/Probability Estimate System

The second function allocation method was intended to be a brief, simplified system designed to provide an effective first-pass over the function allocation process. The first portion of this section provides a description of how the function allocation decision criteria (i.e., those function-oriented decision rules considered by the designer) are identified and further developed for inclusion in this system. This section on criteria development will begin by delineating the process by which we evaluated, judged, and selected criteria for inclusion in the methodology. In the second portion of this section, we describe the rule system (procedures) developed to act on the decisions obtained from the functional criteria. This segment will outline the rule system, describing the means by which the rules were combined and sequenced so as to put responses to the criteria to optimum advantage. In the third portion of this section, the function allocation procedure will be applied to two flight segments in order to evaluate the procedure's relative utility.

Determination of Function Allocation Decision Criteria

As the first step in the determination of the criteria for function allocation, prospective criteria were gleaned from various writings in the field of functional analysis. These prospective criteria were re-worked to fit a common query format for the allocation procedure. In addition, a small number of the candidate criteria were developed analytically.

The prospective criteria were first evaluated in terms of their possible utility for the allocation process. Those candidates whose responses seemed as if they would be equivocal or vague were excluded from further consideration. The remaining prospective criteria were reviewed and critiqued by a panel of aerospace crew systems designers. The panel decided to reject or retain candidate criteria based on the following considerations. First, criteria that appeared redundant, or were inclusive of other criteria, or in some other fashion lacked a clear predictive or diagnostic potential, were excluded by the panel. Second, the panel evaluated the remaining prospective criteria in terms of how important they were to the allocation process. Specifically, the criteria were evaluated in terms of the extent to which they were necessary and/or sufficient decisions to be made regarding a function's allocation. The panel indicated that prospective criteria were either necessary and sufficient, necessary but not sufficient, or neither necessary nor sufficient.

The panel was also asked to evaluate the criteria in terms of whether each candidate's decision was dependent on the context in which the function was to be performed. Criteria were evaluated in terms of context sensitivity in order to provide a principled means to retain criteria that would otherwise be excluded. If, for example, some criterion would indicate that a function would be automated in context A and yet performed by a human in context B, this criterion's allocation utility would be seen as low unless some indication was made of the criterion's dependence on the function's context. Since several important criteria appeared to be context-sensitive in this respect, this seemed to be a reasonable criterion retention strategy.
After panelists made their judgments regarding necessity and sufficiency and context sensitivity, they were asked to indicate how confident they were about these judgments.

The panel's evaluations of these criteria were then analyzed for inter-panelist agreement. Those criteria showing largely similar evaluations with concerning necessity and sufficiency were immediately included as

criteria for the function allocation methodology. Those candidates showing good agreement (2 of 3 raters in agreement) were also retained. Criteria showing marginal agreement were included provisionally, pending further evaluation subsequent to the panel's recommendations. Lastly, those prospective criteria showing poor agreement on the part of the panelists were excluded from further consideration.

Inspection of panelist ratings for criteria demonstrating marginal agreement suggested a straightforward strategy for inclusion of these candidates in the final set of functional criteria: Classify the criterion as fitting the least stringent rating consistent with the panelists' judgments. So, for example, if one rater classified an item as necessary and sufficient, a second rater classified it as simply necessary, and a third as neither necessary nor sufficient, the criterion would be interpreted as validly representing (at least) the weakest of these ratings. A listing of the final function allocation criteria and their assigned classifications (along with their sources in the literature) is provided in Table XIV.

TABLE XIV — FUNCTION ALLOCATION CRITERIA

Function Allocation Criterion	Rationale for Inclusion	Panel Judgment		Source
		Classification	Confidence	
Determination of the feasibility of automating the function	Often, technology limitations, and/ or programmatic considerations must be incorporated early in the determination of a function's allocation.	Necessary and often sufficient	High	Fitts, 1951 (ref.14)
Determination of whether the function is beyond human capacity		Necessary and often sufficient	High	Fitts, 1951 (ref.14); Woodson, 1981 (ref.19); Meister, 1971 (ref.17), and 1985 (ref. 18)
Determination of whether the function involves ambiguous or vague information, or whether it occurs in the context of uncertain events	This criterion was viewed as important since the majority of current automation technologies do not adequately accommodate decision making in situations of uncertainty. (See recent applications of artificial intellegence for notable exceptions to this general rule).	Necessary but not always sufficient	High	Chapanis, 1965 (ref. 16)
Determination of whether the function is essential to the mission's completion, or to safety	The panel's view on this issue reflected a conservative or status quo stance on allocation — namely (a) that whether essential or not, the human would always be at least partly involved, and (b) that only when the function was not essential would a solely automated allocation be entertained.	Necessary but not always sufficient	High	Fitts, 1951 (ref. 14); Meister, 1971 (ref. 17), and 1985 (ref. 18); Rouse and Cody, 1986 (ref. 4)

TABLE XIV — (Continued)

Function Allocation Criterion	Rationale for Inclusion	Panel Judgment		Source
		Classification	Confidence	
Determination of whether errors of misinterpretation could occur	The panel reasoned that only in those cases where a misinterpretation (by either the human or the automated system) was not possible could immediate allocations be made prudently. Since many (if not most) misinterpretations have probably been the fault of the human operator, this criterion was seen as an important diagnostic for 'passing on' the allocation decision farther down the rule scheme.	Necessary and often sufficient	High	Fitts, 1951 (ref. 14); Meister, 1985 (ref. 18)
Determination of whether the function involves monitoring	It is generally accepted that for monitoring tasks human error rates far exceed those of automated systems.	Necessary and often sufficient	High	Fitts, 1951 (ref. 14)
Determination of whether the function involves communication	Since communication often presupposes the crew's (at least eventual) awareness, the extent of crew participation, etc., must be assessed. This criterion is also clearly influential with regard to subsequent functions.	Neither necessary nor sufficient; Context sensitive	Moderate	Flathers, 1987 (ref. 11)
Determination of whether a communication function is strategic or tactical	The separation of strategic and tactical communcation is viewed as diagnostic of a function's allocation because of two general attributes: The duration of the communication, and the specific nature of the decisions and actions required. For tactical communication, rapid, confident judgments about critical situations are often required. In contrast, strategic communications typically lack this time criticality component. Instead, the response requirements are often the results of replanning or data transmission/ updating tasks.	Necessary but not sufficient	High	Flathers, 1987 (ref. 11)

TABLE XIV — (Continued)

Function Allocation Criterion	Rationale for Inclusion	Panel Judgment		Source
		Classification	Confidence	
Determination of whether a monitoring function is based on sensor or system information(e.g., a transponder), or on human perception(e.g., visual acquisition of a TCAS RA)	This criterion was included in order to identify monitoring functions currently under the purview of the human operator, and thereby be able to further evaluate them as candidates for automation.	Neither necessary or sufficient	Moderate	Analytic
Determination of whether a (currently) human monitoring function occurs in a potentially fatiguing situation	This criterion was included because fatigue is a well known contributor to human error. However, since various situations can arise which preclude or discourage automation solutions, this criterion was viewed as context-sensitive.	Neither necessary or sufficient; Context sensitive	Moderate to low	Chapanis, 1965 (ref. 16)
Determination of whether a decision function is continuous, intermittent, or discrete	This descriptor of the nature of a decision function was included to classify the function's gross temporal characteristics.	Neither necessary or sufficient; context-sensitive		Analytic
Determination of whether an intermittent decision (or action) involves a high or low rate of inputs to be considered	This criterion was employed to offer a rough allocation discriminator since logic would dictate that intermittent decisions would be more likely automation candidates if the rate of inputs involved was high.	Neither necessary or sufficient; context-sensitive		Fitts, 1951 (ref. 14); Meister, 1971 (ref. 17)

TABLE XIV — (Continued)

Function Allocation Criterion	Rationale for Inclusion	Panel Judgment		Source
		Classification	Confidence	
Determination of whether a discrete decision's consequent action (or any other action) exhibited a number or complexity of inputs that was low or high	As with the criterion for intermittent decision input rates, this criterion was included as only an approximate discriminator of allocation. A rating of "high" on this criterion generally biased the rule system in favor of automation solutions. A rating of "low" substantantially diminished this tendency toward automation allocation.	Neither necessary or sufficient; Context sensitive	Moderate or Low	Meister, 1971 (ref. 17)
Determination of whether a discrete decision's consequent action (or any other action) is precise or coarse	This criterion was included since coarse (imprecise) movements are often less difficult for humans to perform then are precise movements.	Neither necessary or sufficient; Context sensitive	Low	Woodson, 1981 (ref. 19)
Determination of whether a discrete decision's consequent action (or any other action) is simple or complex	This criterion was included since simple movements are often less difficult for humans to perform than are complex movements.	Neither necessary nor sufficient; Context sensitive	Low	Chapanis, 1965 (ref. 16)
Determination of whether a discrete decision's consequent action (or any other action) is fast or slow	This criterion was included since slow actions are generally more easily performed by humans than are fast actions.	Neither necessary nor sufficient; Context sensitive		Fitts, 1951 (ref. 14); Meister, 1971 (ref. 17)

Development of the Function Allocation Procedure.

To develop a parsimonious yet still principled function allocation scheme capable of incorporating subjects' decision criteria responses, a relatively simple, highly constrained rule system (i.e., organization of decision criteria) was developed. The system's predominant organizational strategy was to force a subject's responses to the decision criteria to be considered sequentially by the allocation scheme in to instantiate precedence contingencies among the relevant decision criteria.

The rule system for this allocation methodology is schematized in Figure 25 and treated in detail in Appendix L. Rules considered first in the allocation process begin at the left most side of the diagram. Please note that decision criteria considered simultaneously are shown as "and" rules: For example, "The function is feasible to automate and the function is not beyond human capacity." At the right-most end of the function allocation diagram (Appendix L) several subjectively determined probability estimates are provided as allocation decisions. These probabilistic allocations constitute a first approximation to the designer's allocation decision.

As can be seen in Appendix L, the employment of rule ordering has the effect of simplifying the allocation decision process to answering a set of questions in a critical sequence.

In this system, the relative importance of a criterion—and thus its approximate position in the ordering—is based on the panelists' ratings of that criterion's level of necessity and sufficiency, and its extent of context sensitivity. Decisions regarding the ordering of two co-equally rated criteria were made analytically, and, in some cases, somewhat arbitrarily. Nevertheless, some general principles were followed in making these decisions.

One principle was to construct the phrasing of the decision criteria such that all logically possible outcomes, save one, would provide allocation solutions. The remaining undecided outcome, "Human/Automation," would serve as the "gate" to the consideration of subsequent decision criteria. A second principle followed was that, to the maximal extent possible, rules or criteria that were nonessential and/or were context-sensitive would be placed relatively "late" in the rule ordering scheme. In this way those items that depended on contextual information would be dealt with last in the decision process, thereby putting off to that point the need for the designer to consider context-specific information. This seemed advisable given the limited means currently available for adequately modeling context-specific constraints on functions.

Some mention should be made about the allocation decisions rendered by this methodology. First, allocations are of two classes: Rule-determined allocations (i.e., those allocations with a probability of 1.00), and allocation decisions that were dependent on varying contexts and therefore were characterized with binary distributions of allocations. This second class of allocation decisions is represented with subjective probabilities. These subjective estimates of probabilities were employed since sensible well-defined (deterministic) rules governing the actual allocations under consideration were not available or were not developed explicitly enough for the present rule format. To verify that the rough approximations implied by these subjective probabilities appeared "reasonable," the estimates were independently evaluated; and, where necessary, modified by two judges. In support of these estimates, it is important to say here that we believed that while arbitrary, the estimates still appeared to afford the designer a rather general "advice" regarding the

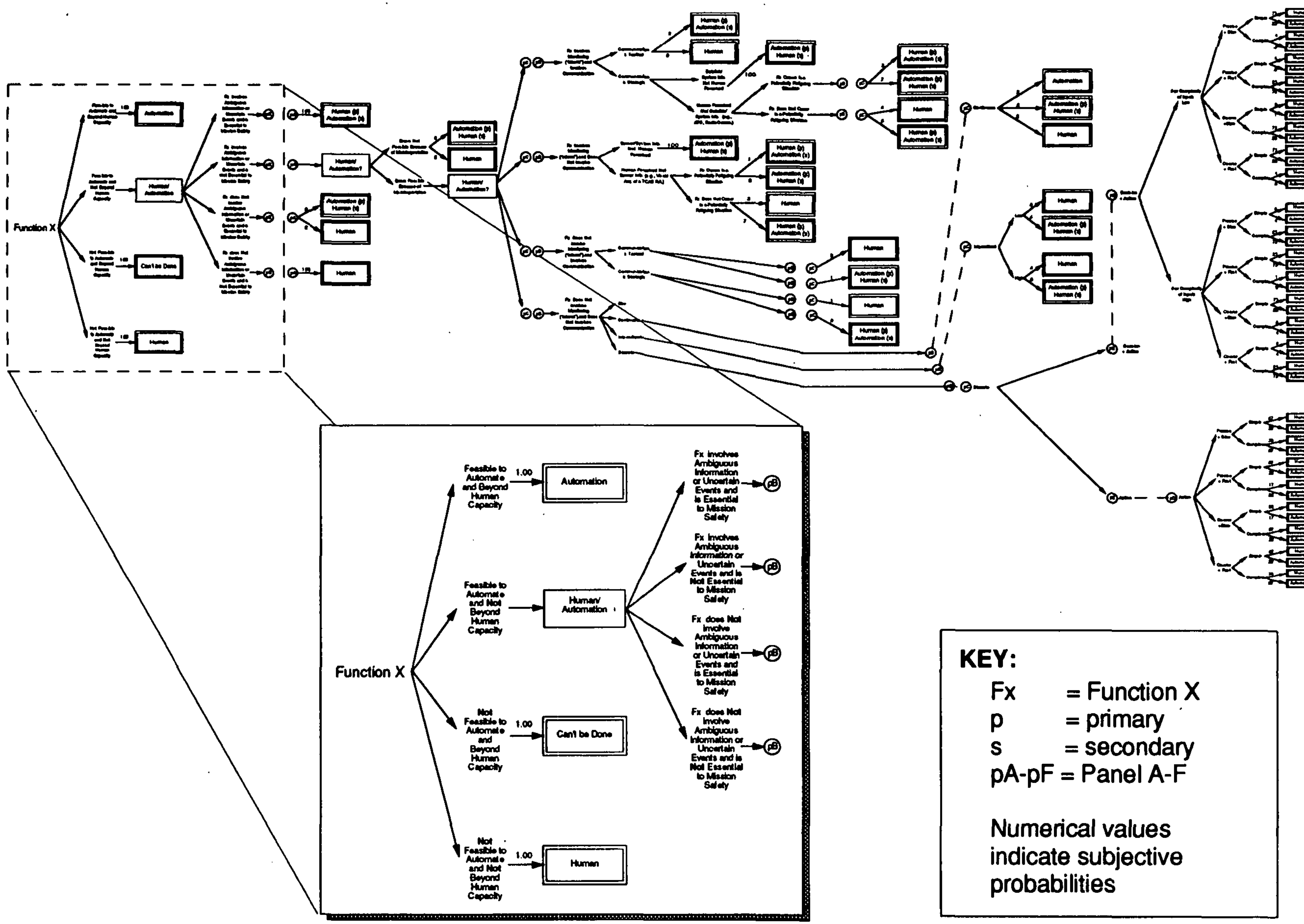

FIGURE 25. SCHEMATIC OF RULE SYSTEM FOR FUNCTION ALLOCATION METHODOLOGY, METHOD B

importance attached to considering the allocations suggested. The apparent heuristic utility of these estimates argues for their provisional incorporation in this methodology.

It should be noted here that the final version of the rule system does not show an explicit delineation of all the logically possible allocation outcomes. This is the case for two reasons. For one, certain of the logically possible allocations (that could result from a given decision criterion) were simply precluded by the rule system at some point earlier in its application. The second reason is that some of the logically possible allocation outcomes were not empirically valid alternatives, given the actual nature of the functions under consideration. In both cases, the decision "tree" of the rule system was "pruned" for clarity of exposition.

Sample Evaluation of Function Allocation Methodology

Two flight segments were chosen on which to perform initial evaluations of the function allocation methodology: The Liftoff segment of the Takeoff phase, and the Descent to Outer Marker segment of the Approach phase. The evaluation process for each phase proceeded as follows. An analyst with experience as a pilot filled out a spreadsheet containing functions associated with the segment under evaluation. The spreadsheet also contained columns associated with each of the function allocation decision criteria. For each function, the analyst was asked to indicate his decisions about the relevant criteria. The analyst was briefed about the complete intent of the question asked in each of the decision criteria to guard against any misinterpretations possible from the abbreviated question format used in the spreadsheet. The analysts' informal evaluations of item wording indicated that, for the most part, the questions were clear and applicable. This generalization notwithstanding, some modifications for readability and interpretability were made as a result of analysts' suggestions. The spreadsheets for the two segments under evaluation are provided in Table M I and M II of Appendix M. In addition to the function listings and analysts' responses to the decision criteria, these spreadsheets also include the allocation decisions rendered by the allocation procedure.
As can be seen in Tables M I and M II, allocation components are generated for each function. Recall that probabilities other than 1.00 and 0.00 are, as stated previously, highly subjective and cannot, therefore, be meaningfully subjected to any mathematical or statistical manipulation. Nevertheless, they can be used to help the designer decide what allocation decision he or she should assign. One strategy the designer might adopt, for example, is simply to pick an acceptance level (say, 0.7) and choose tentative allocations accordingly. Manipulation of this acceptance threshold would, of course, be at the discretion of the designer.

The remaining column in Appendix M is the confidence column. As the name indicates, this is simply a rough index of the designer's confidence in the allocation decision obtained using the methodology. This confidence factor was developed by arbitrarily dividing the rule system into three "tiers," or levels of depth. Those allocations assigned early in the rule system would be classified as high confidence; those assigned in the middle of the system would be classified as medium confidence; and those late in the system as low confidence. These confidence ratings are of course completely reassignable, depending on the designer's intentions and interests.

Initial evaluations of the allocation methodology yielded the allocations presented in Tables M I and M II. Inspection of these allocations caused a concern that the procedure and/or the analysts might be too sensitive to some of the earlier decision criteria since the majority of allocations were made solely on the basis of the first four criteria. Speculation on the source of this possible problem followed several tacks. One speculation was

that pilots' responses to the criterion addressing mission completion and safety would be biased. Pilots, it was argued, might be very cautious in responding to this item. Alternatively, perhaps the particular wording of this criterion, and/or its combination (pairing) with the "ambiguous information/unexpected event" criterion is what resulted in the relatively invariant response pattern. A third possibility is that there was nothing "wrong" with the allocation decisions in these segments. In this case, we do not know whether our choices of evaluation segments were "unfortunate" (in that they just happened to be relatively uninformative segments), or whether the particular allocation decisions generated for these segments should be considered representative of the entire mission.

To investigate this outcome further, the decision rules were modified and a second trial application was accomplished. In this second evaluation, the criteria regarding "mission/safety" and "ambiguous information/ unexpected events" were simply dropped from the rule system, and responses to the remaining criteria were once again interpreted. As expected, the allocation decisions changed considerably. The results of these reevaluations are also shown in Tables M I and M II.

As is evident in these tables, the changes generally favor more shared allocation, with automation frequently taking a primary role and the human taking a secondary role. In addition, a few of the functions allocated to automation in the first evaluation have, in this reevaluation, moved substantially toward an allocation to the human.

While it is difficult to interpret these changes with any degree of certainty, our current speculation about the two excised decision criteria is that, while clearly important to any allocation process, they have not been implemented optimally in the first version of the rule system. It is not clear now whether the appropriate solution to this problem is to re-work the query format of these items (to some sort of "weaker" version of these criteria) or simply to re-situate them elsewhere in the rule system (or to do some combination of these two efforts). In any case, a significant advantage of procedurally explicit allocation methodologies such as this one is that even rather substantial modifications of the allocation procedure can be defined clearly and implemented expeditiously.

FINDINGS AND RECOMMENDATIONS

FUNCTIONAL DESCRIPTION METHODS

Two approaches to the development of a functional description were undertaken during this project. One approach began with very detailed task-timeline (TTL) data and involved first extracting the functions underlying task performance and then expanding the analysis to include areas missing from the original task-timeline data. This approach was called the "Bottom-Up" approach. The other approach began with general functional information and involved decomposing these high level functions into lower level subfunctions. This approach was called the "Top-Down" approach. Both approaches exhibit strengths and weaknesses.

Bottom-Up Approach

The greatest strength of this approach is its ability to address both the time and the sequence requirements associated with each function. This allows one to place functions within a mission framework that clearly shows where and when functions are accomplished. It also allows one to specify dependencies between events and functions, and among the functions themselves, which define the windows of opportunity for functional performance. This provides a valuable preliminary look at the "time available" for task performance that is an important consideration in function allocation and subsequent crew workload analyses. This information may help to identify areas of potential overload early in the design process.

An additional strength associated with this method is its ability to focus on an area of interest and quickly identify functional detail. This makes its use particularly attractive in product development applications, where time and money are scarce, and rapid answers to specific design questions are required. However, this narrow focus carries with it a potential weakness. It is possible that some functions may be overlooked. It is also possible that this bottom-up perspective may not recognize some important functional relationships. A further weakness is that the TTL-based bottom-up approach provides information on the functions that must be accomplished, but does not systematically identify the data necessary to the accomplishment of the functions.

The "Bottom-Up" approach is based on an existing task time line (TTL) database, used to assess flight crew workload as part of the certification process for a new aircraft. The crew procedures are based on a specific design. The detailed nature of the procedures is evident from Figure 3. It was assumed that one could infer from the TTL database the functional requirements that had been implemented during the design process. How this inference was affected by the mechanization of the design, is not known and will not be known until the approach has been applied. A comparison with a "Top-Down" approach showed that, for a given flight segment, similar functions were identified.

Top-Down Approach

IDEFø is a top-down, structured analysis technique that yields a hierarchy of functions needed to accomplish the top objective. In analyzing a large system, the analyst must consider how to deal with complexity. The top-down approach, using IDEFø, has its greatest strength in its ability to deal with complexity, because it starts with a very general level of detail and gradually introduces more detail as the analysis proceeds to lower levels

of analysis. Automated development tools are available to the serious IDEFø user. These tools aid the analyst in decomposing one level diagram into lower levels, it keeps a dictionary of terms developed specifically for each diagram, and many of the off-the-shelf tools have a capability to analyze the structure of the IDEFø model within those boundaries defined by the analyst.

Another strength of the IDEFø-based top-down functional analysis is the capability to extract the information requirements that are essential to the accomplishment of functions at each level of decomposition. Given the time and resources to proceed with decomposition to the required level of detail, the IDEFø methodology has the potential to provide up-front systems design data early-on in the design process and to support early function allocation decisions.

The IDEFø methodology does not address time or sequence, which are important requirements of function analysis. It must be supplemented by other techniques, such as Functional Flow Block Diagrams and Requirements Allocation Sheets (see reference 13), or other methods that emphasize the sequential or concurrent nature of the functions. In common with other knowledge acquisition methods, IDEFø is labor intensive and time-consuming. To achieve a valid representation of the process being modeled, it is necessary to have an analyst who is skilled in the use of the method and has access to a group of subject matter experts from the disciplines relevant to the system being developed.

The "Top-down" approach applied during this contract assumed that the analyst is dealing with a transport aircraft, but the details of the design are not present (in the commercial aircraft world, the new aircraft would probably have many commonalities with the aircraft it is replacing. This helps to minimize production and logistic support costs).

In an IDEFø model, an allocation is indicated by an arrow entering the function box from below. The arrow label tells what the mechanism is (a piece of equipment, a computer program, or a person). The IDEFø model created for this effort has no mechanisms. This means that no allocation has been made or assumed.

Comparison of Approaches

Two alternative approaches to accomplishing functional analysis were compared to ensure that all functions were identified and that the basic decomposition represented a comprehensive perspective of the commercial flight domain. Comparisons were made at three levels of detail. Each level revealed essential consistency between the results that were obtained with each approach. This was reassuring, considering that each approach was developed independently. Each of these comparisons is discussed in the following paragraphs.

The high-level, or macro comparison is shown in Table XV. Here the recurring functions are grouped into comparable categories. Comparison of the two approaches reveals the commonalties that exist at this level. The recurring top-down functions become apparent only after a review of the IDEFø structured decomposition model, where the applicable recurring functions appear as activities embedded within each mission period and/ or mission phase; this structure is due primarily to the analyst's perspective of the decomposition organization and the technique used to accomplish the analysis. In the bottom-up approach these categories result from a consolidation of related functions into meaningful groupings.

TABLE XV — TOP-DOWN / BOTTOM-UP COMPARISON (MACRO)

List of Recurring Functions	
Top-Down	**Bottom-Up**
Communicate	Manage Flight Coordination
Control Aircraft	Manage Aircraft Movement
Navigate	Manage Flight Plan
Manage Aircraft Systems	Manage Aircraft Systems/Procedures
Manage Contingencies	Manage Contingencies

Comparisons are shown at an intermediate level of detail in Figure 26. Here comparison is made between the functions identified in Node A23, "Perform Takeoff," taken from the top-down approach, and functions identified in the analysis format version of the liftoff segment taken from the bottom-up approach. Functions identified as a result of both approaches are compared at the first indenture under the major category levels (e.g., "Manage Flight Coordination," "Manage Aircraft Systems/Procedures," and "Manage Aircraft Movement"). The aircraft control functions listed under Node A232, of the top-down approach, are comparable to F3a, F3b, F3c, F3e, and F3f in the bottom-up approach listing. Again, it can be seen that substantial commonality exists. However, one significant difference was revealed. The IDEFø model did not identify the activity that required the aircraft to capture a specific altitude during this segment. Altitude control was, however, implied through the control of pitch, airspeed, vertical velocity, etc. The bottom-up approach, on the other hand, specifically identified the activity of capturing a designated altitude during liftoff, even though such a level of detail may be the result of procedural activities and not inherently part of the functional organization. However, further decomposition of the IDEFø model may have yielded the needed specificity ir this one area.

Time constraints limited the top-down approach to a small portion of the mission profile for a detailed level comparison. The Takeoff Phase was therefore chosen for this comparison effort and decomposed by the IDEFø model until a level of detail comparable to the bottom-up approach was obtained. A comparison at the lowest (micro) level of detail is shown in Figure 27. Nodes A2322 and A2323, "Control Aircraft Altitude" and "Control Aircraft Airspeed," respectively, are taken from the top-down approach, and compared with the functions found within F3, "Manage Aircraft Movement," from the bottom-up approach. In this comparison the top-down approach states the function of controlling the aircraft's attitude and airspeed in more general terms than those that appear in the bottom-up approach.

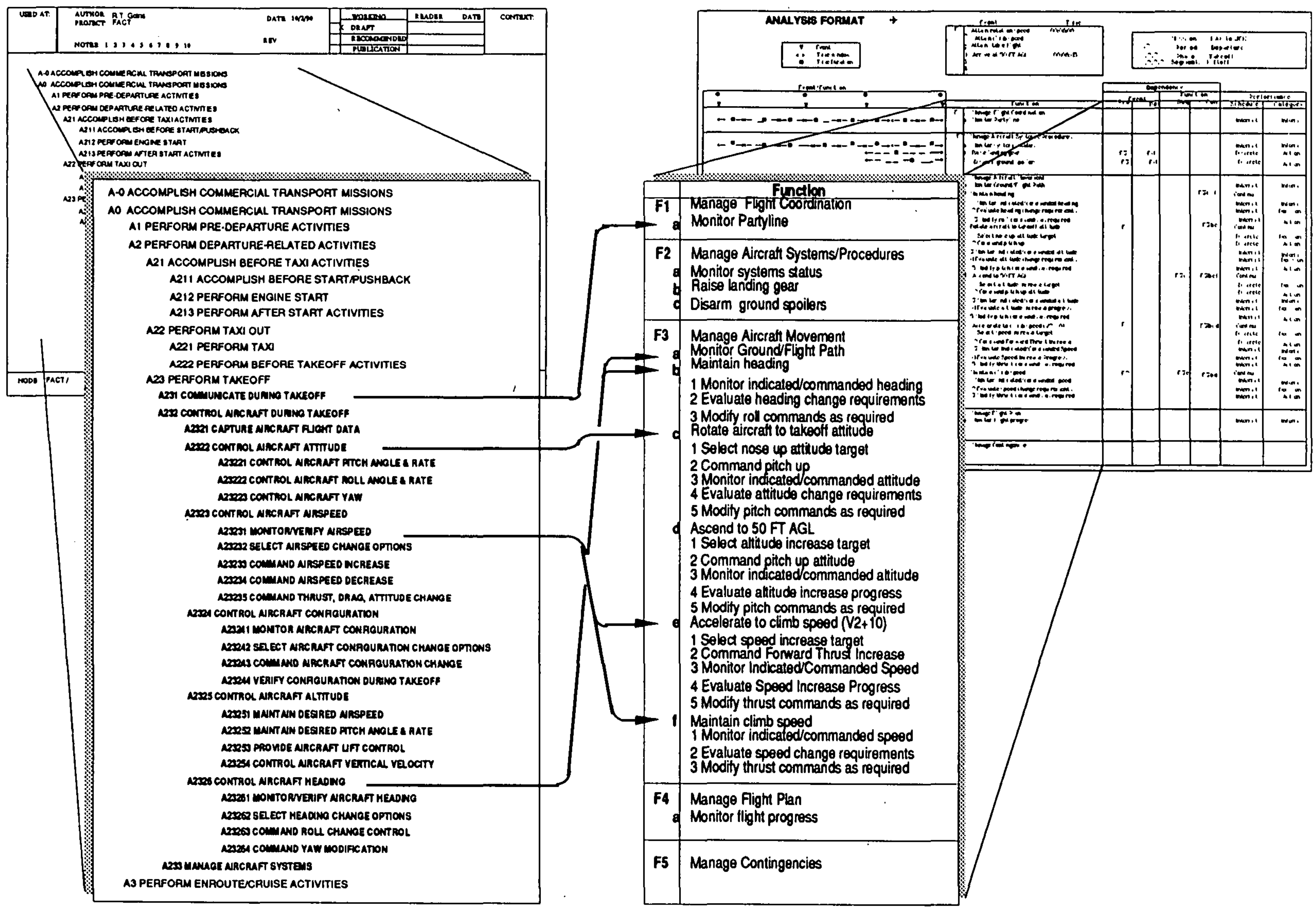

FIGURE 26. TOP-DOWN / BOTTOM-UP COMPARISON (INTERMEDIATE)

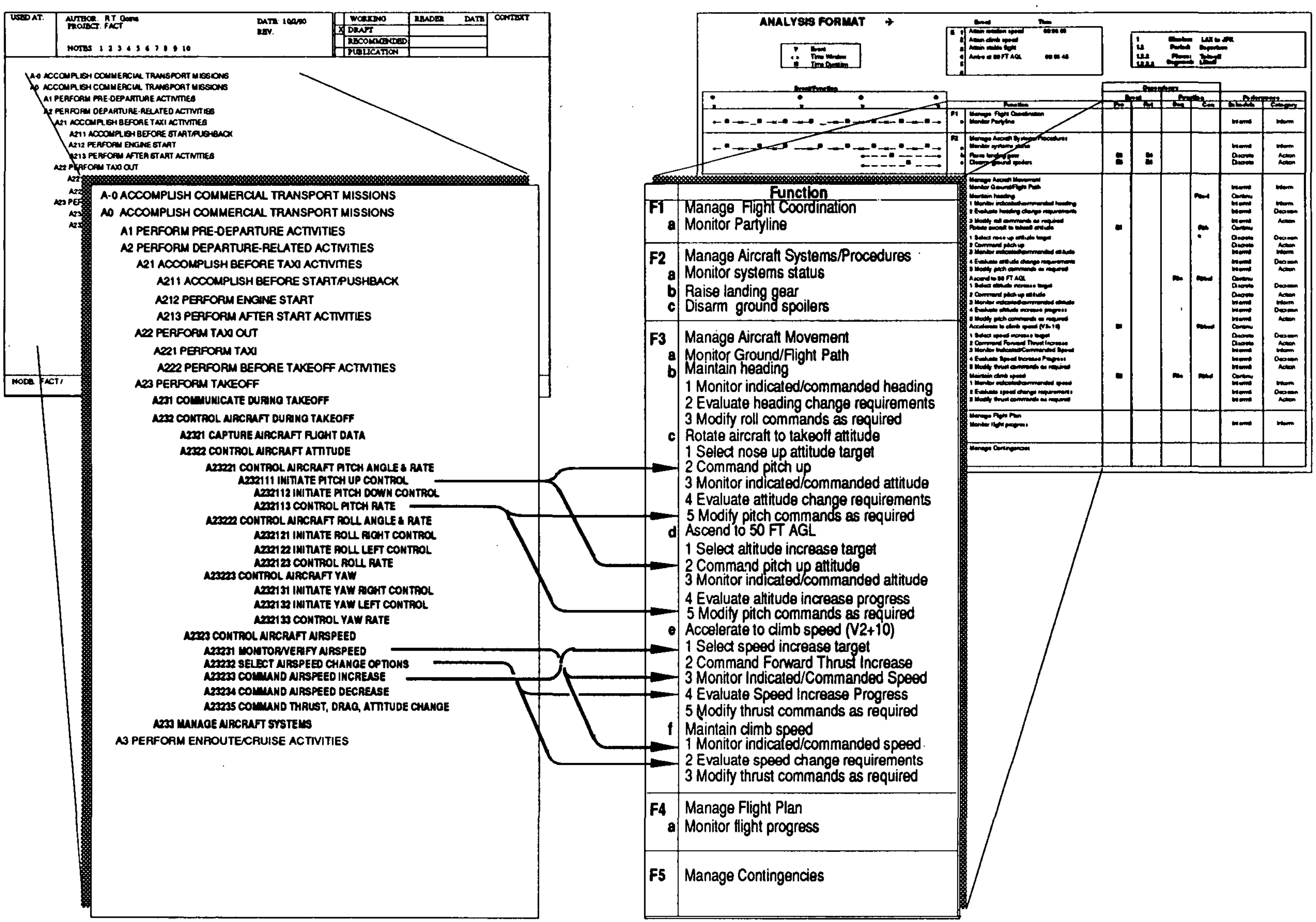

FIGURE 27. TOP-DOWN / BOTTOM-UP COMPARISON (MICRO)

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Conclusions

Because of its origin in the task-timeline (TTL) database, the bottom-up approach gave more insight into the sequential flow of functions. It also gave an insight into what was occurring within a specified period. The presentation of the bottom-up analysis using the analysis format (see Appendix G) provided a clearer portrayal of the sequence of events matched against a task-timeline. The top-down approach, using the IDEFø method, provided a more comprehensive hierarchical model of functional requirements, but did not address the sequence of events. It has the potential for providing data that are not available from the TTL database. Considering the strengths and weaknesses of the two approaches some recommendations for the use of each may be offered. Where much task detail exists for similar systems, a bottom-up type approach may be of greater utility. One can very quickly generate functional detail that is tailored to realistic, time sequenced, system operations. Where very little detail exists, because a substantially new design is being developed to perform a unique mission, then a top-down approach is clearly the only viable approach to generating functional requirements.

Between these two extremes it may be possible to apply the two techniques in a complementary fashion to take advantages of the strengths of each approach. For example, a bottom-up type approach could be used to generate the time sequenced functional detail, while the top level functional organization could be generated using a top-down type approach. The top-down approach could also supply data needed for function accomplishment. One should therefore consider the relative utility of these approaches to be dependent upon the nature of the design problem under investigation.

FUNCTION ALLOCATION METHODS

In the course of this research, two methodologies for function allocation were formulated, tested, and evaluated: A comprehensive, data-intensive iterative system, and a more abbreviated system having relatively few data requirements. Evaluation of both methodologies was hampered by the dearth of knowledge regarding the relative capabilities of humans and automated systems. This lack of a "comparative psychology" of functional capabilities notwithstanding, evaluations of the two methodologies were performed and are presented here. While the two systems share several important similarities, it is their differences that are perhaps more elucidating to the present investigation of function allocation. With this assumption in mind, the characteristics of each method are summarized and then discussed in terms of their relative strengths and weaknesses.

Method A: Heuristic/Iterative System

Overview

This first approach to function allocation employs a progressive, iterative decision process that could be integrated with a system engineering effort. The methodology is based on the assumption that a function allocation system must influence the design decision process at every stage of development—from initial design requirements, to early design implementations, and even to all subsequent activities from prototyping to

development. In this approach, the iterative process is perhaps the essential systems engineering aspect of their methodology.

Broadly speaking, Method A comprises two main components: A complex, extensive decision criterion database, and a multi-stage inspection/decision process designed to use the knowledge represented in the database. This iterative decision process generates initial and subsequent function allocations. The database is relational, involving several inter-connected fields, each explicating an aspect of a function's description and its relation to other functions and the mission as a whole. Together, these fields constitute the conceptual "feature" or attribute matrices descriptive of the functions under consideration. The principal advantage of this arrangement of the knowledge structure is the relative ease and flexibility with which virtually any search or sort can be conducted.

The second component of Method A, the iteratively implemented decision process, employs various procedural constraints or rules that operate on specified segments (i.e., from functions under consideration) accessed from the database. These "operators" are of four general types: Time and timing constraints, human characteristics (e.g., workload), aircraft and ATC system capabilities, and design factors. Using these operators, the decision process evaluates the relevant segments of the database to first identify functional similarities among relevant functions, and later to identify discriminators between these related functions. In this fashion, functions are characterized so as to enable the designer to make sensible, principled allocation decisions.

Advantages

The successful implementation of Method A promises to offer several noteworthy advantages. First, it is a relatively comprehensive approach to knowledge representation (regarding functional requirements germane to the crew system and the aircraft), and knowledge retrieval and evaluation. It has the rather enviable appeal of having addressed, or at least formally broached, many of the classic issues that have engaged researchers in function allocation since the field's inception. In this respect, in particular, Method A has been quite responsive to the research community's demand for a more than superficial treatment of the function allocation problem.

Also owing to this approach to knowledge representation is the advantage of providing a database modular enough, and therefore flexible enough, to incorporate changes to the database in a relatively straightforward manner. (In this respect, this approach is reminiscent of more formally "frame-" based systems. It would seem apparent that future modifications to the present formulation of the database would consider such organizational options). However, it is not clear whether the analogous advantage is possible for Method A's rule component since these rules, as stated previously (see ref. 4), are so general as to preclude evaluation in this regard. Nevertheless, Method A's overall approach to the problem suggests that the procedural system is probably quite flexible as well.

Perhaps the most provocative potential advantage of this methodology is the possibility that it could adequately address the problem of context-driven variation in function allocation decisions. While detailed, rigorous examples of such context-specific allocations are still forthcoming from this method, it is apparent that the system is at least capable of explicating the characteristics involved in accounting for the effects of context. This capability is even more attractive when one considers that the data and decision requirements involved in

the explication of contextual effects are (at least) a large subset of the requirements involved in such automation concepts as "adaptive" or dynamic, on-line function allocations.

Disadvantages

The most apparent disadvantage of this process is its reliance on an extremely labor-intensive data gathering and data encoding effort for all subsequent function inspection activities. This problem is compounded by the fact that, in several cases, it is not clear whether the data required by the method is, today, adequately describable, or even attainable by any means. One is, therefore, somewhat reluctant to engage in the rather substantial level of effort required to obtain these data when there is no clear indication that the data will be of actual utility in making function allocation decisions. Before a data field is developed and incorporated into the system, some preliminary assessment is required of that data field's probable diagnostic value vis-a-vis function allocation. In its present form, the practical utility of this function allocation methodology to an actual aircraft development and production program is questionable at best.

It is perhaps more appropriate to view the Method A methodology as a general template from which to generate system-specific function allocation schemes. The substantial attention paid to the formal characteristics of the function database, and to the iterative process of applying allocation decision rules throughout the design process—these concerns are perhaps best suited to the development of a general function allocation "philosophy," and not to the actual treatment of a specific function allocation problem since pragmatic and programmatic constraints would inevitably pervert this methodology. In short, the Method A methodology, as currently formulated, seems best suited to act as a "bridge" between engineering-theoretic and applications-oriented concerns regarding function allocation. In this capacity, this approach is ideal as a starting point for the development of function allocation schemes tailored to individual system applications.

Method B: Decision Rule/Probability Estimate System

Overview

It seems reasonable to characterize this second function allocation methodology as a rule-ordered (i.e., constrained) version of a Fitts-List type allocation mechanism. In general terms, the rule system can be broken down into two phases or types. Initially, the decision criteria (typically necessary and sufficient ones) are constrained to follow well-defined allocation rules. These are the rules found early on in the rule scheme. As decision criteria become progressively less vital (e.g., neither necessary nor sufficient) to mission success and more sensitive to the contexts in which they occur, the rule system (at a coarse level) provides subjective estimates of the likelihood of particular allocation solutions. In this respect, this system is clearly a "first pass" procedure, simply giving the designer general guidelines for initial allocations. Of course, there is nothing preventing the designer from using this system in an iterative fashion. For example, one could simply re-apply the methodology every time that the change in a baseline aircraft concept resulted in a different functional decomposition.

Advantages

The Method B methodology embodies a number of substantive advantages. For one, the technique is straightforward and requires relatively little time to administer. It relies on readily obtainable data—subject

ratings regarding the decision criteria. And, since these criteria were derived principally from issues long regarded as important to the problem of function allocation, the technique offers at least preliminary construct validity for its criterion choices.

Another advantage is that the rule system incorporates the more clearly important decision criteria early on in the rule sequence, thereby ensuring that those decisions constrain all subsequent, more contextually sensitive decisions. The explicit nature of the rule system offers (at least) two important advantages. First, it is in a format that allows any criticisms of it to be made precisely and to be evaluated clearly. The rationale for a given function allocation decision can be easily ascertained by tracing the path through the logic tree. Second, the system's explicitness allows it to be modified easily: Rule ordering can be changed; rules can be added or deleted; subjective (i.e., analytically determined) probability estimates can be modified to reflect the knowledge and experience of a particular user. Allocation decision thresholds (e.g., 0.8 and above: accept the allocation) can be raised and lowered to adjust for the relatively conservative nature of the allocations.

Disadvantages

The brevity of the Method B methodology is of course a weakness of the approach in that possibly significant factors have been excluded from consideration. This concern is somewhat ameliorated by the ease with which new decision criteria can be added to the rule system. Nevertheless, this criticism of the technique remains significant.

A more serious limit to the Method B methodology is the decision to use a sequential rule (rule-ordering) system. The choice to employ such a system may have resulted in artificially and/or erroneously constraining the allocation process, thereby artificially preventing the application of potentially relevant criteria downstream. In short, we do not know the extent to which the Method B methodology effectively differs from the mental model of the designers (nor do we know whether this is a non-optimal characteristic of the Method B system).

A third limitation of the Method B methodology was the choice to use subjective probability estimates of allocation decisions. The assignment of subjective probabilities only "postpones" dealing with the real problem of coming up with a mechanism for modeling (or at least accounting for) the effects of contextual variation on allocation decisions. Moreover, an outline for a principled approach to dealing with context effects might look like is not readily apparent upon inspection of the current Method B formulation. The best that can be said is that at least the system's employment of subjective probabilities allows for initial allocations to be made in accord with contextual constraints.

Related to the problem of modeling contextual effects is the fact that the Method B's rule system does not incorporate an explicit means by which dynamic or adaptive allocation can be achieved. While post hoc mechanisms could certainly be implemented to this end, the position adopted for Method B was that it would be premature to incorporate such a capability, owing to the lack of definitive knowledge upon which to base appropriate decision rules.

APPLICATIONS OF FUNCTIONAL ANALYSIS

Experience gained during the conduct of this investigation has provided much insight into the capabilities and limitations of functional analysis methodology. When this knowledge is viewed in the context of traditional system engineering principles and current aircraft design practice, a number of conclusions may be drawn regarding the practical utility of these techniques as applied to development of advanced cockpit automation concepts. In summarizing these conclusions, a distinction will be made between product development and research applications.

Product Development Applications

This study has demonstrated, compared and contrasted several alternative techniques for applying system engineering principles in the definition of functional requirements for a transport aircraft cockpit. When employed as an integral part of a well-structured engineering and developmental test program, these analyses can provide the basis for logical and consistent application of the human-centered design philosophy. Functional analysis provides a mechanism for translating the operational requirements of the vehicle into meaningful design requirements for the engineer. The techniques demonstrated in this study can also help assure that design decisions regarding cockpit automation are based upon balanced consideration of relevant alternatives and available resources. The authors of this report feel that the discipline, traceability and accountability that these procedures impose on the design process can have a substantial positive impact on the operational utility and safety of future transport aircraft cockpits.

In addition to the primary role of this methodology in function allocation, functional analysis can provide a number of other tangible contributions to the process of development and certification of cockpits for future aircraft. These may be summarized as follows:

- ***Assure Comprehensiveness***—A detailed functional description can serve as a "checklist" for the designer to help assure that the design solutions will accommodate all anticipated operational requirements (including contingencies).

- ***Prioritize Development Needs***—A comprehensive functional analysis can help surface critical, high risk or conflicting design requirements early in the development process so that appropriate action can be taken to resolve these issues or explore alternatives with minimal commitment of engineering resources.

- ***Facilitate Comparisons and Tradeoffs***—The functional organization can provide a basis for making analytical comparisons among alternative design solutions that are functionally equivalent.

- ***Facilitate Functional Integration***—The hierarchical structure of the database can assist the designer in establishing the organization and overall architecture of the crew interface (e.g., functional grouping of controls, displays, related information, etc.).

- ***Provide Evaluation Criteria***—Analysis of mission requirements and performance specifications for the air vehicle should assist in defining relevant evaluation criteria for use in developmental and qualification tests to demonstrate compliance with customer and regulatory requirements.

While the potential benefits to be gained by using these methods are considerable, the nature of the development cycle for commercial aircraft imposes some important limitations on the practicality of using functional analysis methods in the initial stages of design. In contrast with military aircraft programs, the burden of commercial aircraft development costs must be borne entirely by the airframe manufacturer. Since the level of investment required is extremely large, the pressures to minimize development costs are considerable. In addition, potential airline customers normally require a fairly detailed design before committing to order new aircraft, exerting additional pressure on the manufacturer to minimize front end analysis and proceed with product definition. These factors serve to restrict severely the time and resources that are typically made available for analysis of system requirements.

It should also be noted that the FAA imposes demanding flight safety requirements for aircraft certification. Compliance with these requirements has traditionally required a lengthy test and evaluation process employing conservative criteria and well established measurement techniques with demonstrated validity and reliability.

In view of these considerations, it is evident that available methods for functional analysis and allocation suffer from several significant deficiencies. These may be summarized as follows:

- ***Cost and Schedule Impact***—The techniques presently available for functional analysis are time-consuming and costly. Implementation of a rigorous top-down approach such as IDEFø is particularly labor-intensive. While the procedures for recording, editing, and manipulating a functional description may be greatly facilitated by using a sophisticated database management system, the process of knowledge acquisition demands many hours of dedicated effort by a skilled team of analysts with direct access to subject matter experts in aircraft systems and flight operations. For this reason, the costs associated with conducting a thorough and comprehensive analysis of all flight deck-related operations may be prohibitive in the context of a commercial aircraft development program. Further streamlining of the functional analysis process may be required to achieve the desired level of practical utility.

- ***Lack of Definitive Criteria for Function Allocation***—Meaningful decision rules for function allocation should be based upon objective (and preferably quantitative) data regarding the relative capabilities and limitations of humans and automation. While general principles and qualitative criteria have been proposed from time to time in the literature, a comprehensive body of empirical research and comparative data is lacking. Because the relative effectiveness of man and machine is "context sensitive," involving interactions among numerous variables, predictions based on the "rule of thumb" approach can have only limited predictive accuracy. Further empirical research on human/machine performance is required to establish the necessary parametric criteria and multivariate predictive models for function allocation.

- *Need for Validation in the Operational Environment*—The true benefits to be derived from the application of functional analysis methods as design aids can only be fully assessed through empirical testing of the end product. Presumably, a more structured and human-centered approach to design of cockpit automation would result in enhanced performance of both crew and automated subsystems. The magnitude and practical significance of performance improvements could be demonstrated through the use of flight simulation techniques to evaluate new design concepts in comparison with conventional implementations. It seems probable that this type of validation will be necessary in order to gain general acceptance of the system engineering approach to cockpit design by industry and regulatory agencies. Recent work by Abbott (ref.13) is a paradigm of the approach that is needed. Abbott applied function/task analysis to the design of the Engine Monitoring and Control System (E-MACS) to implement a design philosophy intended to provide information better suited to the user's task than displays designed with traditional methods. Initial validation of the approach was accomplished using part-task simulation. Flight tests are currently underway to provide operational validation (personal communication).

While the factors cited above serve to limit some of the applications of functional analysis methods, it is evident that there is an important role for these analytical tools in support of the cockpit design process. The concerns identified above suggest the need for further development and refinement of functional analysis techniques to enhance their practical utility.

Research Applications

Functional analysis methodology offers a powerful set of tools for researchers engaged in the study of advanced aircraft automation concepts. Since research applications are exploratory in nature and may often deal with relatively limited subsets of the functional domain, many of the practical constraints that limit product development applications would not necessarily inhibit their utility in a research environment. The operational knowledge embodied in a detailed functional description is an essential prerequisite to the successful development of many kinds of advanced automation concepts. Functional analysis provides an organizing framework for capturing this knowledge about the functional requirements of the air vehicle and translating it into a form that is readily accessible and useful for the computer scientist. As more definitive information about the relative capabilities of man and machine is acquired, a well-designed knowledge representation scheme can provide the necessary flexibility and growth capability to accommodate modifications to the decision rules for function allocation. As our knowledge base matures, the adaptation of sophisticated software tools such as 4th Dimension and Nexpert to this purpose may ultimately provide the mechanisms needed to model the complex interdependencies among functions and their associated information requirements.

APPENDIX A

REVIEW OF PRIOR RESEARCH

Today, almost forty years after Paul Fitts proposed his list of qualitative criteria for allocating functions to men or to machines, there does not exist a well-defined, generally-accepted, validated, user-friendly model of the process for integrating human beings into the design of systems, such that the resulting product meets its performance objectives. The United States Air Force has recognized the problem and implemented actions intended to improve the situation. Examples are AFSCM 375-5, "Systems Engineering Management Procedures" (ref. 13), and the Air Force Integrated Computer-Aided Manufacturing (ICAM) and Technology Modernization (Tech Mod) Programs (ref. 3).

Since Fitts proposed his list of qualitative decision criteria for function allocation, human engineering practitioners working on large, primarily military systems, have invented or acquired techniques to help them make a useful contribution to the system development effort they were supporting. These tools have gradually been collected into handbooks to assist new human factors engineers to interact effectively with the rest of the design team.

In the paragraphs which follow, some of the relevant literature will be summarized, but a detailed review of various techniques will not be attempted. All the references cited have been reviewed and many contain lists of additional sources. The largest, most ambitious, and potentially most beneficial research and development effort ever mounted to deal with system engineering in crew station design is the U. S. Air Force Cockpit Automation Technology Program. Because of its potential importance to all persons concerned with the flight deck, this program will receive special attention in this review.

HUMAN ENGINEERING / TECHNIQUES-ORIENTED WORKS

The problem of function allocation was first addressed by Paul Fitts in 1951 (ref. 14). Fitts directed a multidisciplinary study of the air navigation and traffic control system which existed in the United States in 1950. In the report of that study, Fitts discussed the kinds of tasks which human beings do better than machines and those which machines can perform better than human beings. The two sets of qualitative criteria have become known as "The Fitts List." The original Fitts List is given in Table A-I.

In his article (ref. 15), Jordan criticized the Fitts List approach because it compares the functions which man can do better than machines to those which machines can do better than man. Jordan argued that men and machines are not comparable. Rather, they are complementary. In Jordan's view, if a task is predictable, controllable, and iterative and requires consistent performance, a production machine is a better choice than a human being for accomplishing the function. Where the task environment is not predictable, or is predictable, but is not controllable, a human being with the appropriate tools is the

TABLE A-I — THE ORIGINAL FITTS LIST

Human Beings Are Better than Machines at:

1. Ability to detect small amounts of visual or acoustic energy.
2. Ability to perceive patterns of light or sound.
3. Ability to improvise and use flexible procedures.
4. Ability to store large amounts of information for long periods and to recall relevant facts at the appropriate time
5. Ability to reason inductively.
6. Ability to exercise judgment.

Present Day Machines [1951] Are Better than Human Beings at:

1. Ability to respond quickly to control signals, and to apply great force smoothly and precisely.
2. Ability to perform repetitive, routine tasks.
3. Ability to store information briefly, then to erase it completely.
4. Ability to reason deductively, including computational ability.
5. Ability to handle highly complex operations, i.e., to do many different things at once.

better choice. This is because the human being is capable of coping with contingencies, and the machine is not.

Jordan noted that a common practice was to allocate to the man those functions which were either too difficult or too expensive to mechanize. The remaining functions were then allocated to machines. He also pointed out that man had been looked upon as a link in the system and that only the information and capabilities needed to accomplish the task of the link were given to him. The problem which arose from application of this philosophy was that the man was unable to take over manual control when the

system failed. Jordan also emphasized the need to ensure that the allocation of functions to human beings provide a built-in mechanism for motivating the person. In Jordan's view, if this is not done, the man will rebel against the system which tries to treat him as if he were a machine.

Chapanis (ref. 16) summarized the inadequacies of the Fitts List as a basis for making allocation decisions. These include the facts that general man-machine comparisons are often wrong, that it is not always necessary to decide on a component which can do the job better. Often "good enough" may be sufficient. Also, decisions based on a Fitts List do not consider tradeoffs, which are a fact of life for the systems engineer. Chapanis also directs attention to the fact that social, economic, and political values have an impact on function allocation, and that one must continually re-evaluate assignment decisions, because they are sensitive to the engineering state of the art. Chapanis suggests some general guidelines for approaching the problems of function allocation. He also cites the published works (to 1963) of other investigators who were addressing the problem of function allocation in the context of a system.

Meister (ref. 17) described a step-by-step procedure for accomplishing function allocation. In a later work (ref. 18), he greatly elaborated his approach and related it to the Department of Defense military system acquisition cycle. Meister identified behavioral questions which arise during the development of a system, then related these questions to appropriate behavioral methods in a matrix. He also called attention to the difficulties the practitioner may have in applying these methods in the development environment. In Chapter Four of the referenced work, Meister also provides a review of computer-based aids to system development and computerized mathematical models for predicting and evaluating operator performance. In his summary, Meister states that the automated design aids he reviewed were still in an experimental state, although some had been under development for a number of years, and that manual methods were used more often than their automated equivalents. He includes an extensive list of references.

Woodson (ref. 19) provides a useful illustration of the application of functional flow block diagramming to the definition of functional requirements and suggests an approach to function allocation. The difficult problem of integrating the work with the program development plan and schedule is not addressed.

In his 1985 article in *Human Factors* (ref. 20), Price summarized the state of the art relative to function allocation up to that time. His article was later incorporated as a chapter in ref. 21. He noted advances made during the '60s and '70s with the advent of the Department of Defense Military Standard, MIL-H-46855B, *Human Engineering Requirements for Military Systems, Equipment and Facilities,* by the appearance of elaborations of the Fitts List, and by the availability of computer-aided procedures. He also noted that none of the computer-aided procedures had found wide acceptance. Price reports that, in 1981 he had reviewed existing approaches and methods for the allocation of functions for potential application to nuclear power plants and had identified several problems and lessons learned. He discussed four general weaknesses in published methods;

1. There is no formula for computing the suitability of human performance as compared to machine performance, for a given function. Such a formula would require the availability of

large databases of quantitative data on human performance which could be related to the requirements of a new design. Price states that, at the time of his writing, such data did not exist, and probably never would. He concludes that expert judgment will remain the basis for making an allocation decision, augmented by the analyst's past experience with similar systems and by empirical test.

2. The allocation decision is iterative and follows the generate and test paradigm, as designers work the design problem.

3. Psychomotor and cognitive performances differ. Methodologies which work well for air vehicle control are not useful for application to cognitive tasks, such as flight planning or air traffic control. In this connection, Price calls attention to the unfavorable result of assumption of control by computers, leaving the operator out of the loop and ignorant of what is happening. This can lead to a loss of confidence in the automatic control and a decision to override. Other undesirable effects of complete automation of a function are loss of interest, with resultant loss of the ability to intervene intelligently in an emergency. Price holds that designers should deliberately plan for keeping the operator involved while the system is under automatic control.

4. It is not necessarily true, because a human being performs a function poorly, that a machine will perform it well. There are tasks which neither do well. Price presents a decision matrix for allocation functions which addresses the several allocation possibilities. Price then lists eleven general rules for the approach to function allocation.

In the remainder of his paper, Price addresses the system approach to design and makes the statement that, at the level of function analysis, most functions must be allocated to some combination of human beings or machines. In conclusion, Price notes the importance of function analysis and function allocation in avoiding design errors which can be very costly to correct downstream. He emphasizes the need for additional work, especially on analyzing human cognitive requirements in an automated environment.

In their chapter on "Analytic Techniques for Function Analysis" (ref. 22), Laughery and Laughery describe a number of approaches to capturing essential information about operations. In their view, "functional analysis" is synonymous with "process analysis." The focus is on means for modeling systems to make it possible to analyze the system's structural and dynamic properties. The chapter has an industrial engineering flavor, oriented towards general applicability rather than specifically to aircraft systems. The chapter is unusual in that it addresses techniques such as Gantt Charts and PERT/CPM for use in project management. This is a useful contribution, because it introduces human factors personnel to the advantages of these project planning and control methods.

Kantowitz and Sorkin (ref. 23) review the history of function allocation, and describe present practice, with an emphasis on Meister's (ref. 18) procedure. The authors discuss the relationship between allocation and workload and summarize some methods for measuring workload. Finally, they discuss the need for more knowledge of allocation of functions in the manufacturing environment. They

conclude that allocation of functions in manufacturing will proceed in much the same way as it has in human factors in general. The treatment given by the authors is mainly philosophical. They list 41 references.

In their 1986 paper (ref. 4), Rouse and Cody summarize a proposed technique for function allocation in the design of manned systems. The authors review three characteristics which limit the utility of present function allocation methods.

- The process is visualized as taking place during the early part of design. Functional requirements are defined, then an allocation strategy is applied to assign responsibility for each function to the crew or to the remainder of the system (automation/machines). It is assumed that allocation is a one-shot process and need not be considered further.

- Current allocation methods tend to limit the options the designer will consider relative to crew system design. The operator is considered to be a serial information processor of limited capacity, capable of accomplishing only one task at a time. This results in a job design which consists of collections of independent tasks, one task for each function, which the operator is to perform. The operator may be able to perform each task separately, but unable to perform appropriately when several tasks must be accomplished concurrently or occur in rapid succession.

- System functions are partitioned into two mutually exclusive sets, one for human beings and one for computers. This approach fails to take advantage of advances in artificial intelligence and adaptive aiding which permit machines to accomplish intelligent behaviors typically reserved to human beings. These advances make possible function allocation decisions which are situation dependent for those functions that either man or equipment can handle adequately.

The authors suggest an alternative allocation policy which assigns functions dynamically, depending on whether the operator or the computer is better able to accommodate the demand at the moment. They also call attention to their success in demonstrating the feasibility of adaptive allocation schemes in the context of flight management and process control. This approach has been found to result in better total system performance and manageable operator workload, when compared to conventional, static allocation schemes. Rouse and Cody then describe their methodology for function allocation. Their approach includes three phases:

- Initial design

- Design integration

- Final design

The methodology assumes that system objectives have been converted into functional requirements prior to the initial design phase. It also assumes that the functions have been converted into a function time line. The authors do not describe a method for creation of the function time line. According to Rouse and Cody, "The function time line is an estimate of the structure of demands for system resources over time." The objective of their function allocation methodology is to convert the demand structure of the function time line into:

- An allocation timeline which shows the allocation of each function to a human being or to a computer, for each time period. If the allocation is dynamic, the most likely allocation is specified by the timeline.

- For each human-allocated function, a task design which completely describes the task, including displays, controls and procedures, together with the human performance models and data used to design the task.

The detailed application of their approach is described in the main body of this report, beginning on page 28.

In commercial aircraft development, acceptance by the design engineers of the results of research depends critically upon demonstration of the practical utility and operational validity of the work. The approach taken by Abbott (ref. 13) offers a paradigm for meeting these requirements. Abbott applied function /task analysis to the design of the Engine Monitoring and Control System (E-MACS) display to implement a design philosophy intended to provide information better suited to the user's task than displays designed with traditional methods. Initial validation of the approach was accomplished using part-task simulation. Flight tests are currently underway to provide operational validation (personal communication).

SYSTEM-ORIENTED WORKS

Air Force Systems Command System Engineering Management Procedures

Following the end of World War II, in 1945, there was a growing awareness of the need to employ a "system approach" to the development of new military aircraft systems. Prior to this time, aircraft systems had been assembled from available components, often with the capabilities of an aircraft engine as the point of departure, with little regard to the needs of the flight crew. The new philosophy dictated that performance requirements for the new system be derived from the operational mission; that development of the system consider interfaces among all elements of the system, including the human operator; and that tradeoff studies to evaluate the relative merits of alternative design solutions be conducted before making a selection. A massive joint Air Force Systems Command (AFSC)-Industry effort was mounted to capture and document a procedure to be followed to implement the new "system engineering" approach. The Ballistic Missile Division (BMD) of AFSC was given the lead role, but all

AFSC Divisions participated. The result was Air Force Systems Command Manual 375-5, System Engineering Management Procedures, published in March 1966 (ref. 13).

AFSCM 375-5 was one of a series of manuals which provided a procedural baseline for the management of system programs involving a complex of hardware, software, personnel, procedures, facilities and their interfaces with one another and with management. Other manuals in the series addressed Configuration Management and System Program Management.
AFSCM 375-5 established "system engineering" as a guiding principle for the acquisition of Air Force systems. "System engineering" was defined as "organized creative technology." In the context of AFSCM 375-5, "system engineering" included terms such as system approach, system analysis, system integration, functional analysis, system requirements analysis, reliability analysis, maintenance and maintainability task analysis and similar functions. AFSCM 375-5 made two major contributions to a disciplined approach to system acquisition.

- It defined "a common system analysis process which leads to system definition in terms of performance requirements on a total system basis," and

- It provided a "'road map' of engineering actions during a system's life cycle in their relative order of occurrence."

One of the more important tools mandated by AFSCM 375-5 was the Functional Flow Block Diagram (FFBD) and its associated Requirements Allocation Sheet (RAS). The FFBD technique is a top-down, hierarchical method for decomposing higher level functions into subfunctions to the level required to permit allocation. FFBDs also show the required sequence of accomplishment of the functions/activities in a given flow. The RAS is a matrix which documents allocation decisions. Descriptions of each analytic technique and worked examples of their use are given in AFSCM 375-5.

Imposition of AFSCM 375-5 as a contract requirement met with opposition from industry, especially from companies which had been building mainly commercial aircraft. There were several reasons:

- The approach was very labor intensive, hence costly.

- Many engineers did not know the required techniques.

- Many FFBDs had to be generated, at a time when computing assistance was limited to mainframes.

- The correlated AFSCM 375-1 Configuration Management procedures were highly disciplined. Commercial practice was not adequate.

- Engineers rebelled against the discipline imposed on them by the AFSC manuals.

Whatever the reason, AFSCM 375-5 was eliminated as a contract requirement. However, it remains a milestone in the effort to develop an objective, disciplined approach to the acquisition of large, complex systems, where the emphasis is on the functions which must be accomplished, rather than on the responsibilities of organizations.

USAF Integrated Computer-Aided Manufacturing (ICAM) Program

In 1977, the U. S. Air Force launched a five-year, $100 million program intended to increase productivity in aerospace manufacturing, and to provide for a surge capability in the event of national mobilization. This initiative was called the Integrated Computer-Aided Manufacturing (ICAM) Program (ref. 3). A central concept of the ICAM Program was that, in order to improve an existing system, one first had to know how it works now. To capture this information, the ICAM Program acquired or developed appropriate analytic and simulation techniques. These techniques included the function modeling language, $IDEF_\emptyset$ (ICAM Definition Method, Version Zero); the information modeling language, $IDEF_1$; the dynamic modeling language, $IDEF_2$; and the ICAM Decision Support System (IDSS) for simulating alternative design solutions. $IDEF_\emptyset$ was derived from the copyrighted Structured Analysis and Design Technique (SADT) (ref. 24), developed by SofTech, Inc. The ICAM Program Office acquired the right to use the copyrighted methodology and gave it a new name. The other methodologies were developed under the ICAM Program.

The main thrust of the ICAM program was manufacturing and only a relatively small amount of effort was devoted to capturing the architecture of design. The decomposition of the functional architecture of design (ref. 25) did not go down far enough to capture the contributions of specialty disciplines, such as Human Factors Engineering. Also, $IDEF_\emptyset$ does not address time or sequence, which are essential to an adequate description of the process.

The ICAM Program was significant because it promoted the use of analytic and simulation techniques to solve factory problems prior to building or purchasing hardware. It forced management to examine the process for creating its product. Unfortunately, there was a great deal of resistance to the implementation in the factory of the solutions developed under the ICAM Program, primarily because of the demands of implementation upon capital. There was also resistance by management to the discipline imposed by the top-down analysis of the operation. The $IDEF_\emptyset$ modeling technique requires every subordinate function to be logically necessary to the accomplishment of the higher level function/ objective. Duplication of functions, activities without outputs, and lack of interfaces become apparent when this technique is used.

The USAF Cockpit Automation Technology (CAT) Program

The USAF CAT Program is directly relevant to NASA's Aviation Safety/Automation Program because it addresses the development of technology for the design of the crew station and the demonstration of the effectiveness of the new technology. The emphasis is on appropriate automation to permit the pilot/ crew to perform more effectively. Although the CAT Program addresses the fighter mission of the

1990s, which is far more demanding of the pilot than a commercial transport mission, many of the same methodological considerations are involved.

The USAF CAT Program is the largest, most ambitious effort ever directed towards the rigorous specification of the process for designing and evaluating a totally integrated crew system for manned, military flight systems.This section is based on the Requests for Proposal (RFP) for Phase 1 and for Phases 2 and 3 (unpublished data). The treatment given here will enable the reader to understand what is being attempted by the CAT Program and what products are to become available. It is expected that products of the CAT Program will become available when they have successfully completed validation testing and meet Air Force quality standards.

The CAT Program has three phases. Phase 1 was begun in 1984 with the award of contracts to three contractor teams for an 18-month period. Phase 2, Development, was awarded to two contractor teams for a 24-month period in April 1986. Phase 3, Demonstration and Validation, also for 24 months, was awarded to one contractor team.

CAT PHASE 1

Problem

In the past, the primary factors which limited mission performance were the aircraft and its subsystems, not the pilot. In present-day aircraft, pilots must frequently prioritize workload and omit some tasks during critical mission phases. The total workload on Air Force pilots is rapidly approaching unacceptable levels. A new approach is needed to control pilot workload, by assuring that crew systems are developed to use the pilot/crew efficiently.

Objectives

The specific objectives of CAT Phase 1 were, "To characterize and functionally decompose the post-1990 tactical attack mission and build the methodological structure for a new design technology that accounts for (a) adapting to mission uncertainty, and (b) inherent aircrew capabilities/limitations (unpublished data)."

These objectives were to be accomplished by completing four major tasks:

1. Develop a procedural method for integrating cockpit automation technology into the weapon system development process. To assist the contractor in accomplishing this task, a flow diagram of a prototype CAT design process was provided with the RFP.

2. Develop mission characterization tools and procedures. This task included the identification of a baseline weapon system, development of a detailed mission time line, performance criteria, functional decomposition, classification of mission functions into operations variables, decision variables and problem formulation variables, as well as classification of functions as "operator" or "manager" roles.

3. Prepare a preliminary development plan.

4. Identify a set of candidate cockpit automation concepts and evaluate them to show how the aircrew compatibility and tactical effectiveness can be improved through the CAT design process.

Products

The products of CAT Phase I were:

- Definition of the CAT methodology
- Mission characterization
- Development plan for CAT
- Candidate automation concepts

CAT PHASE 2 - DEVELOPMENT

Contracts for CAT Phase 2 were awarded to two contractor teams in April 1986. The RFP required the contractors to bid on Phases 2 and 3, although only Phase 2 would be awarded initially.

The Phase 2 objective was "to develop fully the CAT design process."

Phase 2 included four major tasks:

1. Phase 1 Assessment—The contractor was required to evaluate the Phase 1 results, to supplement them as necessary to accomplish the remaining tasks of Phases 2 and 3, and to prepare a program plan for accomplishing both phases.

2. Fully develop the CAT design process—This task required the contractor to prepare a detailed model of the process of crew system design and to document the process in $IDEF_{\emptyset}$ (ref. 3). Also required were an outline of a Cockpit Automation Design Guide, recommendations for revision to military specifications and military standards, and development of a Lessons Learned Data Base.

3. Apply the CAT Design Process—The contractor was required to prepare a design specification and data necessary to permit fabrication of simulator cockpit hardware and interfaces during Phase 3, and to permit independent evaluation of the CAT cockpit design.

4. Develop a Cockpit Automation Design Support System (CADSS)—This task included the development of software tools, a stand-alone computer-aided design system, and a rapidly reconfigurable (breadboard) cockpit for use by the crew system designer.

CAT PHASE 3 - DEMONSTRATION/VALIDATION

This phase requires the contractor to "demonstrate that the crew system design from Phase 2 is measurably improved, relative to the baseline crew system, as a result of applying the CAT methodology (unpublished data)." Additional requirements included preparation of the Cockpit Automation Design Guide, development of the Breadboard Cockpit design aid, and the development of Computer-Aided Engineering (CAE) software tools for evaluation of pilot performance, workload evaluation, and evaluation of pilot acceptance.

The products of the CAT Program should greatly assist crew system designers. One problem will still remain. That problem is implementation by a given airframe manufacturer. The airframe manufacturer will have had to define the process for accomplishing product definition in its company, to include identification of the specialty disciplines which must play a role, how these disciplines interact with one another, how the whole process maps to the overall system acquisition schedule, what the products of each participating discipline are, who needs them, what they are used for, and when they are needed. For many companies, attitudes will have to be changed to accept each participating discipline as an equal.

APPENDIX B

ACTION VERB LIST

Functional analysis task statements are constrained to the following action verbs:

VERB	DEFINITION
ACCELERATE	To increase the rate of forward movement, to speed up.
ACCESS	To achieve physical possession of, or figurative entry to.
ACKNOWLEDGE	To inform the sender of a message that the communication has been received and is understood.
ACTIVATE	To change a system from a non-operational to an operational status.
ADJUST	NOT to be used. Use tune or modify.
ADVISE	NOT to be used. Use report, announce, etc.
ALERT	To inform that a dangerous or potentially dangerous situation exists.
ALIGN	To bring into correct position.
ANALYZE	NOT to be used. Use evaluate.
ANNOUNCE	To inform crew and/or passengers of conditions or events.
ARM	To place a system or equipment into a cocked or ready state whereby a triggering event will cause a corresponding discrete action or reaction to occur.
ASCEND	To change position from a lower to a higher altitude.
ASSESS	NOT to be used. Use evaluate.
ATTAIN	To achieve or accomplish a desired goal or condition.

BEGIN	NOT to be used. Use initiate.
BRIEF	To verbally communicate a summary of the details of a future or pending mission, task, procedures, etc.
CALL (FOR)	NOT to be used. Use request.
CHECK	NOT to be used. Use test, inspect, etc. instead.
CLASSIFY	To identify membership in a particular group or category.
CLIMB	NOT to be used. Use ascend.
CLOSE	To block passage or flow.
COMMAND	To direct that some event or task sequence be accomplished.
COMMUNICATE	To exchange information, or to make known.
COMPARE	To examine items in order to observe similarities or differences.
COMPUTE	To calculate by mathematical processes.
CONCLUDE	To finalize a decision process.
CONFIGURE	To place a system or component into a particular condition or mode.
CONSIDER	To take account of during decision making.
CONTINUE	To proceed in the performance of some action, procedure, etc. or to remain on the same course or direction.
CONFIRM	Not to be used. Use verify.
CONTROL	To exercise restraining or directing influence over, to fix or adjust the time, amount, or rate of.
COORDINATE	To plan or arrange in a manner that provides an optimal combination of interactions, functions, tasks, etc.
CYCLE	To move or step a system, equipment, or component through a complete sequence of events.

DEACTIVATE	To change a system or component from an operational to a non-operational state.
DEBRIEF	To verbally communicate the details of a completed mission, task, or procedure.
DECELERATE	To decrease the rate of forward movement, to slow down..
DECREASE	To reduce the size or amount of.
DEFINE	To specify the detailed features of.
DEPRESSURIZE	To remove or reduce air pressure from within an aircraft.
DEPOWER	NOT to be used. Use deactivate.
DESCEND	To change position from a higher to a lower altitude.
DETECT	To find or discover the existence of a condition or event.
DETERMINE	To discover or arrive at through a systematic process.
DEVIATE	To alter direction or course from that which was planned or anticipated.
DIRECT	To inform personnel of required action.
DISARM	To place a system, equipment or component into a disabled or harmless condition.
DISCHARGE	To emit or apply material over a target area.
DISENGAGE	To remove a system, equipment or component from a controlling status or function.
DON	To put on equipment or clothing.
ELIMINATE	To make completely unavailable for use or access.
ENGAGE	To place a system, equipment or component into an active, controlling status or function.
ENSURE	NOT to be used. Use verify.

ENTER	To move physically into or to input data.
EVACUATE	To exit with all due speed.
EVALUATE	To perform a critical analysis of conditions or events in order to understand their natures or characteristics.
EXAMINE	NOT to be used. Use inspect.
EXIT	To move physically out of or away from.
EXTEND	To move a structure or component outward from an enclosed to an exposed position.
EXTINGUISH	To smother or quench.
FASTEN	To attach or make secure.
FILL	To pour or put into a receptacle or other holding device.
FLY	To move an aircraft through the sky after it is airborne.
FOLLOW	To control an aircraft in order to align its performance with guidance information.
GUARD	To secure from inadvertent or inappropriate usage.
HEAR	To acquire information aurally.
HOLD	NOT to be used. Use maintain.
IDENTIFY	To establish the nature or characteristics of, through a rational, systematic process.
ILLUMINATE	To provide light to an area or to a display surface.
INCREASE	To augment the size or amount of.
INFORM	NOT to be used. Use report, announce, etc.
INITIALIZE	To ready system or equipment to begin operation.
INITIATE	To begin or commence action or operation.

INPUT	To enter data into a computer.
INSPECT	To perform a systematic visual examination of equipment or structures for specified conditions.
INSURE	NOT to be used. Use verify.
INTERCEPT	To control an aircraft in order to insure a timely alignment (capture) with a specific navigational course, and/or azimuth.
INTERROGATE	To examine or query a system regarding the status or condition of its components.
INVENTORY	To compose or review a listing in order to insure the appropriate amount or quantity is available.
ISOLATE	To locate the cause of an equipment malfunction.
JETTISON	To expel cargo or fuel in an orderly manner.
LAND	To perform actions necessary to bring an aircraft from an airborne to a non-airborne status.
LEVEL	To align an aircraft parallel to the plane of the horizon.
LOAD	To take on cargo (e.g., passengers, baggage, etc.).
LOWER	To move a structure or object in a downward direction, attitude or angle.
MAINTAIN	To remain in a specified position, direction or state.
MODIFY	To adjust in order to achieve a desired state, level or condition.
MONITOR	To continually or periodically observe visual information or listen to or for auditory information in order to assess conditions or operating status.
NAVIGATE	To direct, manage, plot, and/or control the course and position of the aircraft.
NOTIFY	NOT to be used. Use report, announce, etc.
OBSERVE	To look at and assess for possible subsequent action, or to visually confirm a condition or state.

OPEN	To make available for flow or passage.
OPERATE	To control a system or equipment in order to accomplish a specific predetermined purpose.
OUTPUT	To retrieve data from a computer.
PARK	To bring aircraft to a halt in a specified place and position.
PERFORM	To accomplish an entire task, operation or mission, or to accomplish a clearly defined step in a task, operation or mission.
PLAN	To outline or prepare in advance the execution of a procedure, process, etc.
POSITION	To place or arrange appropriately.
PREPARE	To perform actions which precede the start of a specific procedure or operation.
PRESSURIZE	To establish and maintain air pressure within an aircraft.
PREVENT	To ensure an event or action cannot occur.
PROCEED	To move forward or advance in an orderly or regulated manner.
PROGRAM	To enter computer directions.
PROVIDE	To make available for use.
POWER	NOT to be used. Use activate.
RAISE	To move a structure or object in an upward direction, attitude or angle.
READ	To repeat written material aloud to others or silently to oneself.
RECEIVE	To acquire messages, instructions, or flight information.
RECORD	To produce a permanent account of actions or events.
RECOVER	To regain control of.
RELEASE	NOT to be used. Use disengage instead.

REMOVE	To take out of or away from.
REPEAT	To perform an activity more than once.
REPORT	To describe as being in a specified state, condition or location.
RESET	To return to a former position or condition.
RETRACT	To move a structure or component inward from an exposed to an enclosed position.
REQUEST	To solicit desired information or permission.
REVIEW	To perform a critical examination to assess the accuracy or completeness of some body of data.
ROTATE	To pitch the aircraft about its center of gravity.
SCAN	To visually examine using a specific pattern or sequence.
SELECT	To choose from among a number of alternatives.
STABILIZE	To place a system or aircraft from an uncontrolled into a controlled condition or status.
START	To change equipment from a non-operational to an operational state.
STEER	To guide or direct the course of an aircraft.
STOP	To change equipment from an operational to a non-operational state.
STOW	To place an item into a storage location or status.
TAXI	To move on the ground under the aircraft's own power.
TEST	To verify the operational status of a system or equipment.
TRANSMIT	To send information, generally via radio waves.
TRIM	To make a minor adjustment.
TUNE	To adjust for a particular frequency (delete and use align?).

TURN	To change the direction of the aircraft.
UNFASTEN	To release.
UNLOAD	To remove cargo (e.g., passengers, baggage, etc.).
UPDATE	To modify in order to conform to more recent data.
VERIFY	To make certain by some direct act or observation that a desired or necessary action, task, operation, etc., has been performed or accomplished.

APPENDIX C

GENERIC AIRCRAFT SYSTEMS

Propulsion System

Oil System
Starting System
Ignition System
Fuel System

Primary Flight Control System

Roll Control System
Pitch Control System
Yaw Control System

Secondary Flight Control System

Lift Augmentation System (flaps/slats)
Drag Augmentation System (spoilers)

Automatic Flight Control System

Auto Pilot System
Auto Throttle System
Flight Director System

Flight Management System

Flight Planning
Aircraft Guidance System
Flight Progress Monitoring System
Performance Monitoring System

Landing Gear/Braking System

Nose/Center/Main Landing Gear System
Ground Control System (nose wheel/rudder pedals)
Ground Braking System (parking/maneuvering brakes)

Instrumentation and Navigation System

- Inertial Reference System
- VOR/Marker Beacon System
- Distance Measuring Equipment System
- Automatic Direction Finding System
- Instrument Landing System
- Radio Altimeter System
- Air Data System
- Standby Instrument System
- Traffic Alert/Avoidance System
- Electronic Flight Instrument Display System

Electrical Power System

- Battery Power System
- Auxiliary Power System
- Emergency Power System
- Primary Power System

Lighting System

- Emergency Lighting
- Internal Lighting System
- External Lighting System

Hydraulic Power System

- Primary Hydraulic Power System
- Auxiliary Hydraulic Power System

Air System

- Air Conditioning System
- Pressurization System
- Pneumatics System

Fire Detection System

- Engine/APU Fire Detection system
- Cargo/Cabin Fire Detection System

Warning And Alerting System

Central Aural Warning System
Electronic Instrument System Alerting
Ground Proximity Warning System

Communications System

Voice Recorder System
UHF Radio System
VHF Radio System
HF Radio System
Passenger Address System
Interphone System

APPENDIX D

GLOSSARY

TERM	DESCRIPTION
Event	An occurrence of relative importance to mission and function conduct. It serves a pivotal role in the constraint or enablement of function initiation or termination. Where an event serves as the boundary between segments it is time-marked according to its location in the mission scenario.
Event Dependency	The relationship which exists between functions and events such that the performance of a function is contingent upon the occurrence of a reference event. This relationship may be either proactive or retroactive in nature. Proactive dependency requires that a function not be initiated until the occurrence of a reference event. Retroactive dependency requires that a function be completed before the expected occurrence of a reference event.
Function	A goal directed activity which must be successfully accomplished to satisfy a mission or system requirement. It is stated in terms of an action verb and noun object.
Function Allocation	The assignment of functions to humans or system automation based on a set of criteria that takes into consideration the strengths and weaknesses of each along with other relevant data (e.g., cost, reliability, etc.).
Function Analysis	The process of decomposing higher level function into an hierarchy of lower level functions. It is continued to increasing levels of detail until a point is reached where it is possible to allocate functions between humans and automation.
Function Dependency	The relationship which exists between functions such that the performance of one function is contingent upon the performance of another function. This relationship may be sequential or concurrent in nature. Sequential dependency requires that one function be completed before another can be initiated. Concurrent dependency requires that functions be performed simultaneously.

Performance Category The classification of functions according to the nature of the process involved in their accomplishment. The categories are information, decision, action, and communication. These categories are applied at the lowest functional level. The decision category includes those functions which involve information processing, problem solving and decision making. The communication category includes those functions which involve the transmission and reception of information, instructions and messages, both internal to as well as external to the aircraft. The information category includes those functions which involve the search for and receipt of sensory information. The action category includes those functions which involve control of the aircraft and its systems.

Performance Duration The time required to perform a function. This is aircraft configuration driven.

Performance Schedule The schedule by which a function is evoked. It way be continuous, intermittent, or discrete in nature. A continuous schedule consists of variable, but uninterrupted, performance of a function. A discrete schedule consists of a single, non-recurrent performance of a function. An intermittent schedule consists of multiple, recurrent performances of a function, each separated by a period of inactivity.

Performance Window The time window within which a function must be performed. This is mission scenario driven.

APPENDIX E

NORMAL FLIGHT FILE

This database lists the functions required to accomplish the normal mission. The database organizes the data according to the location of the functions in the mission hierarchy. For example, at the top of page E-2, the location of the function in the mission hierarchy is indicated in the following way:

1 MISSION: NORMAL FLIGHT, LAX TO JFK
1.1 PERIOD: PRE-DEPARTURE
1.1.1 PHASE: PRE-FLIGHT
1.1.1.1 SEGMENT: PLANNING & PREPARATION

The functions which comprise the Planning and Preparation segment are listed in the order in which they occur. The functions are decomposed to three levels.

The event which marks the beginning of the segment is indicated in the right margin. In the case of segment 1.1.1.1, Planning and Preparation, the segment is initiated when the flight crew arrives at the Operations Center. The initiating event is indicated for each subsequent segment. Some segments have events in addition to the event which marks the beginning of a segment. Events tie the accomplishment of functions to the mission timeline.

1 MISSION: NORMAL FLIGHT, LAX TO JFK

1.1 PERIOD: PRE-DEPARTURE

1.1.1 PHASE: PREFLIGHT

1.1.1.1 SEGMENT: PLANNING & PREPARATION

FUNCTIONS	EVENTS
	ARRIVE AT OPERATIONS CENTER

FUNCTIONS

- DETERMINE FLIGHT CONSTRAINTS
  - REVIEW FLIGHT SCHEDULE
    - IDENTIFY ORIGIN/DESTINATION LOCATIONS
    - IDENTIFY DEPARTURE/ARRIVAL TIMES
  - REVIEW WEATHER FORECAST
    - IDENTIFY PRECIPITATION CELL LOCATIONS
    - IDENTIFY THUNDER CELL LOCATIONS
    - IDENTIFY WIND SPEED, DIRECTION & LOCATION
    - IDENTIFY DEPARTURE/ARRIVAL VISIBILITY/CEILINGS
  - COMPUTE AIRCRAFT FLYING RANGE
    - IDENTIFY FUEL CAPACITY
    - COMPUTE FUEL CONSUMPTION RATE
    - DIVIDE CAPACITY BY CONSUMPTION RATE
  - REVIEW TERMINAL CONSTRAINTS (alt, speed, runway, etc.)
    - IDENTIFY DEPARTURE TERMINAL CONSTRAINTS
    - IDENTIFY ARRIVAL TERMINAL CONSTRAINTS

- DETERMINE OPTIMAL HORIZONTAL PROFILE
  - DEFINE DEPARTURE ROUTE
    - SELECT DEPARTURE PROCEDURE
    - SELECT WAYPOINTS
    - DEFINE LEGS (distance/azimuth)
  - DEFINE CRUISE ROUTE
    - SELECT WAYPOINTS
    - DEFINE LEGS (distance/azimuth)
  - DEFINE ARRIVAL ROUTE
    - SELECT ARRIVAL PROCEDURE
    - SELECT WAYPOINTS
    - DEFINE LEGS (distance/azimuth)
    - SELECT APPROACH PROCEDURE

- DETERMINE OPTIMAL VERTICAL PROFILE
  - DEFINE TAKEOFF/LANDING PERFORMANCE
    - IDENTIFY ADEQUATE PERFORMANCE FOR AIRPORT/ENVIRONMENT
    - DEFINE CRITICAL TAKEOFF/LANDING SPEEDS
  - COMPUTE ALTITUDE/SPEED PROFILES
    - COMPUTE OPTIMUM/REQUIRED ENROUTE ALTITUDES
    - IDENTIFY OPTIMUM CLIMB/DESCENT SPEEDS
    - COMPUTE OPTIMUM CLIMB/DESCENT SCHEDULE
  - COMPUTE DETAILED TIME SCHEDULE
    - COMPUTE LEG ELAPSE TIMES
    - COMPUTE WAYPOINT ETAS
  - COMPUTE FUEL REMAINING AT EACH WAYPOINT

- PLAN FOR DEPARTURE/ARRIVAL CONTINGENCIES
  - PLAN FOR DEPARTURE CONTINGENCIES
    - DEFINE ABORT PROCEDURE
    - DEFINE GO AROUND PROCEDURE
  - PLAN FOR ARRIVAL CONTINGENCIES
    - DEFINE MISSED APPROACH PROCEDURE
    - DEFINE ROUTE TO ALTERNATE AIRPORT
    - DEFINE ALTERNATE APPROACH PROCEDURE

- RECORD FLIGHT PLAN
  - FORMAT FLIGHT PLAN
  - STORE FLIGHT PLAN

COMMUNICATE WITH AIR TRAFFIC CONTROL
    TRANSMIT FLIGHT PLAN FOR ATC APPROVAL
    REQUEST SUBSEQUENT FLIGHT PLAN CLEARANCE DELIVERY

1.1.1.2 SEGMENT: SYSTEMS INITIALIZATION

ARRIVE AT AIRCRAFT

VERIFY EXTERNAL SAFETY PRECAUTIONS
    VERIFY PORTABLE FIRE EXTINGUISHMENT PROVISIONS (fire bottles)
    VERIFY STATIC ELECTRICITY FIRE DANGER REDUCED (A/C grounding)
    VERIFY INADVERTENT AIRCRAFT MOVEMENT PREVENTED (CHOCKS)

VERIFY AIRCRAFT NOSE COMPONENTS AIR WORTHINESS
    VERIFY RADAR PULSE EMITTING/SENSING CAPABILITY UNDIMINISHED
    VERIFY AIRCRAFT DYNAMIC PRESSURE SENSING CAPBLTY UNDIMINISHED
    VERIFY AIRCRAFT ATTITUDE SENSING CAPABILITY UNDIMINISHED
    VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
    VERIFY COCKPIT OVER-PRESSURE RELIEF CAPABILITY UNDIMINISHED

VERIFY NOSE GEAR & WHEEL WELL COMPONENTS AIR WORTHINESS
    VERIFY LANDING GEAR PROTECTION CAPABILITY UNDIMINISHED
    VERIFY LANDING GEAR EXTENTION/RETRACTION CAPABILITY UNDIMINISHED
    VERIFY STEERING CAPABILITY UNDIMINISHED
    VERIFY HYDRAULIC POWER DISTRIBUTION UNDIMINISHED
    VERIFY ELECTRICAL POWER DISTRIBUTION UNDIMINISHED
    VERIFY TIRE CONDITION/INFLATION ACCEPTABLE
    VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
    VERIFY FORWARD LANDING/TAXI ILLUMINATION CAPABILITY ACCEPTABLE

VERIFY RIGHT FORWARD FUSELAGE COMPONENTS AIR WORTHINESS
    VERIFY FWD CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
    VERIFY R LATERAL LANDING/TAXI ILLUMINATION CAPABILITY ACCEPTABLE
    VERIFY STATIC PRESSURE SENSING CAPABILITY UNDIMINISHED
    VERIFY MID CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
    VERIFY LOWER FORWARD CARGO ENTRY/EXIT CONDITION ACCEPTABLE
    VERIFY CABIN OVER-PRESSURE RELIEF CAPABILITY UNDIMINISHED
    VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
    VERIFY O/WING CABN CREW/PASSENGER EXIT CONDITION ACCEPTABLE
    VERIFY R LAT GROUND & NACELLE ILLUMINATION CAPABILITY UNDIMINISHED
    VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE

VERIFY RIGHT WING AND ENGINE COMPONENTS AIR WORTHINESS
    VERIFY LEADING EDGE LIFT AUGMENTATION CAPABILITIES UNDIMINISHED
    VERIFY LATERAL CONTROL CAPABILITIES UNDIMINISHED
    VERIFY ENGINE PROTECTION PROVISIONS CONDITION/SECURITY ACCEPTABLE
    VERIFY REVERSE THRUST CAPABILITIES UNDIMINISHED
    VERIFY FUEL VENTING AND DUMPING CAPABILITIES UNDIMINISHED
    VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
    VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
    VERIFY TRAILING EDGE LIFT AUGMENTATION CAPABILITIES UNDIMINISHED
    VERIFY NAVIGATION SIGNALING CAPABILITIES UNDIMINISHED

VERIFY RIGHT GEAR & WHEEL WELL COMPONENTS AIR WORTHINESS
    VERIFY LANDING GEAR PROTECTION PROVISIONS CONDITION ACCEPTABLE
    VERIFY LANDING GEAR EXTENTION/RETRACTION CAPABILITY UNDIMINISHED
    VERIFY HYDRAULIC POWER DISTRIBUTION UNDIMINISHED
    VERIFY ELECTRICAL POWER DISTRIBUTION UNDIMINISHED
    VERIFY TIRE CONDITION/INFLATION ACCEPTABLE
    VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE

VERIFY CENTER GEAR & WHEEL WELL COMPONENTS AIR WORTHINESS
    VERIFY LANDING GEAR PROTECTION PROVISIONS CONDITION ACCEPTABLE
    VERIFY LANDING GEAR EXTENTION/RETRACTION CAPABILITY UNDIMINISHED
    VERIFY HYDRAULIC POWER DISTRIBUTION UNDIMINISHED
    VERIFY ELECTRICAL POWER DISTRIBUTION UNDIMINISHED
    VERIFY TIRE CONDITION/INFLATION ACCEPTABLE
    VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
    VERIFY FUEL LEAKAGE ABSENT

VERIFY CENTER AFT FUSELAGE LOWER SURFACE COMPONENTS AIR WORTHINESS
  VERIFY FUEL LEAKAGE ABSENT
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE

VERIFY RIGHT AFT FUSELAGE COMPONENTS AIR WORTHINESS
  VERIFY AFT CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY CENTER LOWER CARGO ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY APU INTAKE/EXHAUST CAPABILITY UNDIMINISHED

VERIFY EMPENNAGE & ENGINE COMPONENTS AIR WORTHINESS
  VERIFY ALL MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY LONGITUDIONAL CONTROL CAPABILITY UNDIMINISHED
  VERIFY FUEL VENTING CAPABILITIES UNDIMINISHED
  VERIFY ENGINE PROTECTION PROVISIONS CONDITION/SECURITY ACCEPTABLE
  VERIFY REVERSE THRUST CAPABILITIES UNDIMINISHED
  VERIFY YAW CONTROL CAPABILITIES UNDIMINISHED

VERIFY LEFT AFT FUSELAGE COMPONENTS AIR WORTHINESS
  VERIFY AFT CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY CENTER LOWER CARGO ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY APU INTAKE/EXHAUST CAPABILITY UNDIMINISHED
  VERIFY AFT LOWER CARGO ENTRY/EXIT CONDITION ACCEPTABLE

VERIFY LEFT LANDING GEAR & WHEEL WELL COMPONENTS AIR WORTHINESS
  VERIFY LANDING GEAR PROTECTION PROVISIONS CONDITION ACCEPTABLE
  VERIFY LANDING GEAR EXTENTION/RETRACTION CAPABILITY UNDIMINISHED
  VERIFY HYDRAULIC POWER DISTRIBUTION UNDIMINISHED
  VERIFY ELECTRICAL POWER DISTRIBUTION UNDIMINISHED
  VERIFY TIRE CONDITION/INFLATION ACCEPTABLE
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY APU GROUND CONTROL ACCESS CONDITION ACCEPTABLE

VERIFY LEFT WING & ENGINE COMPONENTS AIR WORTHINESS
  VERIFY LEADING EDGE LIFT AUGMENTATION CAPABILITIES UNDIMINISHED
  VERIFY LATERAL CONTROL CAPABILITIES UNDIMINISHED
  VERIFY ENGINE PROTECTION PROVISIONS CONDITION/SECURITY ACCEPTABLE
  VERIFY REVERSE THRUST CAPABILITIES UNDIMINISHED
  VERIFY FUEL VENTING AND DUMPING CAPABILITIES UNDIMINISHED
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
  VERIFY TRAILING EDGE LIFT AUGMENTATION CAPABILITIES UNDIMINISHED
  VERIFY NAVIGATION SIGNALING CAPABILITIES UNDIMINISHED

VERIFY LEFT FORWARD FUSELAGE COMPONENTS AIR WORTHINESS
  VERIFY FWD CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY L LATERAL LANDING/TAXI ILLUMINATION CAPABILITY ACCEPTABLE
  VERIFY STATIC PRESSURE SENSING CAPABILITY UNDIMINISHED
  VERIFY MID CABIN CREW/PASSENGER ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY LOWER FORWARD CARGO ENTRY/EXIT CONDITION ACCEPTABLE
  VERIFY CABIN OVER-PRESSURE RELIEF CAPABILITY UNDIMINISHED
  VERIFY AERODYNAMIC SURFACE CONDITION ACCEPTABLE
  VERIFY O/WING CABIN CREW/PASSENGER EXIT CONDITION ACCEPTABLE
  VERIFY R LATERAL GROUND & NACELLE ILLUMINATION CAPBLTY UNDIMINISHED
  VERIFY MAINTENANCE ACCESS CONDITION ACCEPTABLE
  VERIFY AIR PRESSURE OUTFLOW UNDIMINISHED (valves fully open)
  VERIFY GROUND PNEUMATIC INTAKE PREVENTED (connectors capped)

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITIES
  MONITOR PARTYLINE

COMMUNICATE WITH LA GROUND CONTROL
  REPORT SYSTEMS INITIALIZATION IN PROGRESS

INSPECT AIRCRAFT FORMS/LOGBOOK

VERIFY FUEL LOADED
VERIFY MAINTENANCE COMPLETED

VERIFY INTERNAL EMERGENCY PROVISIONS ADEQUACY
VERIFY LANDING GEAR EMERGENCY LOCKING PROVISIONS (gear pins)
VERIFY EMERGENCY ESCAPE HATCH CUTTING PROVISIONS (fire axe)
VERIFY PORTABLE FIRE EXTINGUISHMENT PROVISIONS(fire extinguisher)
VERIFY PORTABLE OXYGEN SUPPLY PROVISIONS (O2 bottles & masks)
VERIFY EYE SMOKE PREVENTION PROVISIONS (smoke goggles)
VERIFY EMERGENCY ESCAPE HATCH DESCENT PROVISIONS (ropes)
VERIFY PERSONNEL FLOTATION PROVISIONS (life vests)

VERIFY BATTERY POWER AVAILABILITY
VERIFY BATTERY POWER SYSTEM IS ACTIVATED

VERIFY ELECTRICAL POWER SYSTEM DISTRIBUTION COMPLETE
VERIFY ALL CIRCUIT BREAKERS CLOSED

VERIFY DRAG AUGMENTATION SYSTEM CONFIGURATION WILL NOT CHANGE
VERIFY ALL CONTROL SURFACES RETRACTED
VERIFY SYSTEM NOT ARMED

VERIFY LIFT AUGMENTATION SYSTEM CONFIGURATION WILL NOT CHANGE
VERIFY CONTROL SURFACE POSITION MATCHES COMMANDED POSITION

VERIFY LANDING GEAR SYSTEM CONFIGURATION WILL NOT CHANGE
VERIFY LANDING GEAR EXTENSION COMMANDED

VERIFY AIRCRAFT WILL NOT MOVE INADVERTENTLY
VERIFY PARKING BRAKE SYSTEM ENGAGED
VERIFY GROUND MANEUVERING BRAKE SYSTEM ENGAGED

PROVIDE AIRCRAFT INTERNAL ILLUMINATION
ACTIVATE/MODIFY COCKPIT LIGHTING LEVEL AS REQUIRED
ACTIVATE/MODIFY CABIN LIGHTING LEVEL AS REQUIRED

VERIFY FUEL WILL NOT DISCHARGE INADVERTENTLY
VERIFY FUEL DUMP VALVE CLOSED
VERIFY FUEL MANIFOLD DRAIN VALVE CLOSED

VERIFY PROP AND AUX ELECT POWER FIRE DETECTION SYSTEM OPERABILITY
INITIATE SYSTEM TEST
ACTIVATE FIRE DETECTION LOOPS
VERIFY VISUAL & AURAL WARNINGS ANNUNCIATE
RESET ALARMS
TERMINATE SYSTEM TEST

ACTIVATE AUXILIARY ELECTRICAL POWER/AUX AIR SYSTEM
INITIATE APU START-UP SEQUENCE
PROVIDE AIR INTAKE/EXHAUST TO APU
OPEN APU INLET/OUTLET DOORS
START APU FUEL PUMP
PROVIDE STARTING TORQUE TO APU
PROVIDE FUEL SUPPLY TO APU
START APU FUEL PUMP
OPEN APU FUEL SUPPLY VALVE
PROVIDE IGNITION SPARK TO APU
VERIFY START-UP WAS SUCESSFUL
VERIFY NO WARNINGS ANNUNCIATED
VERIFY ELECTRICAL POWER AVAILIABILITY
VERIFY APU GENERATOR ONLINE
PROVIDE AUXILIARY POWER TO AIRCRAFT SYSTEMS
CLOSE AUXILIARY POWER DISTRIBUTION BUS
VERIFY PNEUMATIC AIR AVAILABILITY
VERIFY APU PNEUMATIC PRESSURE NORMAL
PROVIDE COOLING AIR SUPPLY TO COCKPIT/CABIN
OPEN AUXILIARY POWER SYSTEM PNEUMATIC ISOLATION VALVE
CLOSE PROPULSION SYSTEM PNEUMATIC ISOLATION VALVES
OPEN AIR CONDITIONING PACK FLOW VALVES

SELECT ZONE TEMPERATURE LEVELS
MONITOR ZONE TEMPERATURE LEVELS
MODIFY ZONE TEMPERATURE LEVELS AS REQUIRED

VERIFY ALL ELECTRONIC DISPLAY LUMINANT OPERABLE
ACTIVATE ALL LUMINANTS
VERIFY ALL ILLUMINATE FULLY
DEACTIVATE LUMINANTS

CONFIGURE INERTIAL REFERENCE SYSTEM (IRS)
INITIATE IRS ALIGNMENT
INITIALIZE ALTITUDES
INITIALIZE VELOCITY INTEGRTN FUNCTNS
INITIALIZE POSITION INTEGRTN FUNCTNS
SELECT LAT/LONG REFERENCE
VERIFY ALIGNMENT COMPLETE

VERIFY CABIN/CARGO FIRE DETECTOR SYSTEM OPERABILITY
INITIATE SYSTEM TEST
ACTIVATE FIRE DETECTION LOOPS
VERIFY AURAL & VISUAL WARNINGS ANNUNCIATE
RESET ALARMS
TERMINATE SYSTEM TEST

VERIFY COCKPIT VOICE RECORDER SYSTEM OPERABILITY
INITIATE SYSTEM TEST
VERIFY RECORDING LEVEL ADEQUATE
VERIFY AURAL INDICATION OF TEST SUCCESS
TERMINATE SYSTEM TEST

VERIFY CARGO AREA TEMPERATURES ACCEPTABLE
VERFIY AFT CARGO AREA TEMPERATURE LEVELS
VERIFY FWD CARGO AREA TEMPERATURE LEVELS

VERIFY PROPULSION SYSTEM OPERABILITY
VERIFY ENGINE CONTROLLER PRIMARY MODE AVAILABILITY
VERIFY ENGINE IGNITION SYSTEM FUNCTIONS INACTIVE

VERIFY GROUND PERSONNEL SAFETY
DIRECT GROUND CREW TO STAND CLEAR FOR HYDRAULIC SYSTEM TEST
RECEIVE GROUND CREW ACKNOWLEDGEMENT OF SAFETY CLEARANCE

VERIFY HYDRAULIC POWER SYSTEM OPERABILITY
ACTIVATE ONE AUXILIARY PUMP
VERIFY ASSOCIATED SYSTEM HYDRAULIC PRESSURE ADEQUATE
ACTIVATE SECOND AUXILIARY PUMP
ACTIVATE ONE TRANSFER PUMP
VERIFY ASSOCIATED SYSTEM HYDRAULIC PRESSURE ADEQUATE
DEACTIVATE FIRST TRANSFER PUMP
ACTIVATE SECOND TRANSFER PUMP
VERIFY ASSOCIATED SYSTEM HYDRAULIC PRESSURE ADEQUATE
DEACTIVATE SECOND TRANSFER PUMP
DEACTIVATE FIRST AUXILIARY PUMP
VERIFY ASSOCIATED SYSTEM HYDRAULIC PRESSURE ADEQUATE
DEACTIVATE SECOND AUXILIARY PUMP

VERIFY EMERGENCY ELECTRICAL POWER SYSTEM AVAILABILITY
ARM EMERGENCY ELECTRICAL POWER SYSTEM

VERIFY FUEL SYSTEM OPERABILITY
ACTIVATE EACH FEED PUMP
VERIFY EACH FEED PUMP PRESSURE ADEQUATE
DEACTIVATE EACH FEED PUMP
ACTIVATE EACH TRANSFER PUMP
VERIFY EACH TRANSFER PUMP PRESSURE ADEQUATE
DEACTIVATE EACH TRANSFER PUMP
OPEN EACH CROSS-FEED VALVE
VERIFY EACH CROSS-FEED VALVE OPENS
CLOSE EACH CROSS-FEED VALVE

VERIFY EACH CROSS-FEED VALVE CLOSES
INITIATE FUEL QUANTITY GAGING SYSTEM TEST
VERIFY VISUAL INDICATION OF TEST SUCCESS
TERMINATE SYSTEM TEST

VERIFY EMERGENCY LIGHTING SYSTEM OPERABILITY/AVAILABILITY
INITIATE SYSTEM TEST
VERIFY VISUAL INDICATION OF TEST SUCCESS
TERMINATE SYSTEM TEST
ARM EMERGENCY LIGHTING SYSTEM

VERIFY PERSONNEL SAFETY
ACTIVATE NO SMOKING WARNING ANNUNCIATION
ACTIVATE SEAT BELTS WARNING ANNUNCIATION

PROVIDE/ELIMINATE AIRCRAFT EXTERNAL ILLUMINATION AS REQUIRED
ACTIVATE NAVIGATION LIGHTING
ACTIVATE AIRLINE IDENTIFICATION LIGHTING AS DESIRED
VERIFY NOSE TAXI/LANDING LIGHTING NOT ACTIVATED
VERIFY MAIN LANDING LIGHTING NOT ACTIVATED
VERIFY GROUND FLOOD LIGHTING NOT ACTIVATED
VERIFY WING & NACELLE SCANNING LIGHTING NOT ACTIVATED
VERIFY UPPER & LOWER ANTI-COLLISION LIGHTING NOT ACTIVATED
VERIFY HIGH INTENSITY RECOGNITION LIGHTS NOT ACTIVATED

VERIFY EMERGENCY EVACUATION WARNING SYSTEM AVAILABILITY
ARM EMERGENCY EVACUATION WARNING SYSTEM

VERIFY GROUND PROX WARNING SYSTEM OPERABILITY/AVAILABILITY
INITIATE SYSTEM TEST
VERIFY ALL VISUAL & AURAL WARNINGS ANNUNCIATE
TERMINATE SYSTEM TEST
ARM SYSTEM

VERIFY FLIGHT CONTROL SYSTEM CONSTRAINTS SPECIFIED
SELECT AIRSPEED LIMITING OF FLAP EXTENSION
SELECT AIRSPEED REGULATION OF ELEVATOR LOAD FEEL
VERIFY YAW DAMPING OF DUTCH ROLL SELECTED
VERIFY TRIMMING OF LONGITUDINAL CONTROL SELECTED

VERIFY CABIN PRESSURIZATION SYSTEM OPERABILITY
SELECT ALT/FLT PHASE REGULATION OF CABN PRESSRZTN
VERIFY CABIN PRESSURIZATION OUTFLOW VALVE OPEN
VERIFY DITCHING OVERRIDE FUNCTIONS NOT ACTIVATED

VERIFY ICE AND RAIN PROTECTION SYSTEM NOT ACTIVATED
VERIFY WING ANTI-ICE SYSTEM NOT ARMED
VERIFY TAIL ANTI-ICE SYSTEM NOT ARMED
VERIFY ENGINE ANTI-ICE SYSTEM NOT ACTIVATED
VERIFY WINDSHIELD ANTI-ICE SYSTEM NOT ACTIVATED
VERIFY WINDSHIELD DEFOG SYSTEM NOT ACTIVATED

VERIFY PRIMARY BAROMETRIC ALTITUDE CORRECT
VERIFY REQUIRED BAROMETRIC PRESSURE UNITS SELECTED (in/hp)
VERIFY REQUIRED BAROMETRIC ALTITUDE REFERENCE SELECTED(f.e./s.l.)
SELECT BAROMETRIC PRESSURE CORRECTION FACTOR

CONFIGURE STATIC PRESSURE SENSING SYSTEM
SELECT STATIC PRESSURE SENSING SOURCE
CONFIGURE ELECTRONIC INSTRUMENT SYSTEM (EIS)
SELECT EIS DATA SOURCE
VERIFY FLIGHT DIRECTOR SYSTEM NOT ACTIVATED
VERIFY CENTRAL AIR DATA COMPUTER SYSTEM NOT ACTIVATED
VERIFY INERTIAL REFERENCE SYSTEM NOT ACTIVATED
VERIFY FLIGHT MANAGEMENT SYSTEM NOT ACTIVATED
VERIFY VHF OMNIDIRECTIONAL RANGE (VOR) SYSTEM NOT ACTIVATED
VERIFY FLIGHT GUIDANCE SYSTEM NOT ACTIVATED

INSPECT PRIMARY INSTRUMENT DISPLAY SYSTEM

VERIFY FAULT INDICATIONS ABSENT
VERIFY COMPASS HEADING CORRECT
VERIFY TAKEOFF MODE SELECTED
VERIFY GMT TIME REFERENCE CORRECT
SELECT ELAPSE TIME REFERENCE (zero)

INSPECT LANDING GEAR WARNING SYSTEM
VERIFY LANDING GEAR FULLY EXTENDED AND LOCKED
INITIATE LANDING GEAR WARNING TEST
VERIFY VISUAL & AURAL WARNINGS ANNUNCIATE
TERMINATE LANDING GEAR WARNING TEST
VERIFY WARNINGS CEASES

CONFIGURE STANDBY INSTRUMENT SYSTEM
SELECT STANDBY ALTITUDE INDICATOR BAROMETRIC REFERENCE PRESSURE
VERIFY STANDBY ATTITUDE INDICATOR ERECT
VERIFY POWER FAILURE INDICATIONS ABSENT

TEST EMERGENCY OXYGEN SYSTEM AND MASK COMMUNICATION SYSTEM
VERIFY MASK PROPERLY STOWED
MODIFY INTERPHONE RECEIVER AUDIO LEVEL
MODIFY COMM MONITOR SPEAKER AUDIO LEVEL
VERIFY PURE OXYGEN SUPPLY SELECTED
ACTIVATE INTERPHONE MICROPHONE
ACTIVATE DEMAND REGULATED OXYGEN FLOW
VERIFY MOMENTARY OXYGEN FLOW VISUAL & AURAL INDICATION
DEACTIVATE INTERPHONE MICROPHONE
ACTIVATE CONTINUOUS OXYGEN FLOW
VERIFY CONTINUOUS OXYGEN FLOW VISUAL INDICATION
DEACTIVATE CONTINUOUS OXYGEN FLOW
VERIFY OXYGEN FLOW CESSATION
DEACTIVATE DEMAND REGULATED OXYGEN FLOW

INSPECT EMERGENCY POWER GENERATION SYSTEM
VERIFY AIR-DRIVEN POWER GENERATION SYSTEM NOT ACTIVATED

INSPECT MANUAL TRIM SYSTEMS
VERIFY DIRECTIONAL (rudder) TRIM NULLED
VERIFY LATERAL (aileron) TRIM NULLED

INSPECT WEATHER RADAR SYSTEM
VERIFY SYSTEM NOT ACTIVATED

CONFIGURE ATC TRANSPONDER SYSTEM
VERIFY TRANSPONDER SYSTEM AT STANDBY
SELECT ATC ID
INITIATE SYSTEM TEST
VERIFY TEST SUCCESSFUL

CONFIGURE VHF,UHF & HF COMMUNICATIONS SYSTEMS
SELECT VHF COMMUNICATIONS TRANSCEIVER
SELECT ACTIVE FREQUENCY
SELECT STANDBY FREQUENCY
REPEAT FOR EACH ADDITIONAL TRANSCEIVER (VHF, UHF & HF)

CONFIGURE AUDIO CONTROL SYSTEM
SELECT COMM/NAV RECEIVER
SELECT AUDIO LEVEL
REPEAT FOR EACH RECEIVER
REPEAT FOR FLIGHT INTERPHONE & PUBLIC ADDRESS SYSTEMS

INSPECT AIRCRAFT SYSTEMS STATUS
ACCESS SYSTEM SUMMARY STATUS DISPLAY
REVIEW ALERT INDICATIONS
RESET ALERTS WHERE POSSIBLE
VERIFY SYSTEMS STATUS ACCEPTABLE FOR FLIGHT

INSPECT FUEL SYSTEM CONFIGURATION
VERIFY ALL FEED PUMPS DEACTIVATED

VERIFY ALL TRANSFER PUMPS DEACTIVATED
VERIFY ALL CROSS-FEED VALVES CLOSED
VERIFY ALL FILL VALVES CLOSED

TEST THRUST COMMAND TAKEOFF WARNING SYSTEM
SELECT MAXIMUM THRUST COMMAND ON ENGINE 1
VERIFY AURAL WARNING ANNUNCIATION
SELECT IDLE THRUST COMMAND ON ENGINE 1
VERIFY AURAL WARNING CEASES
SELECT MAXIMUM THRUST COMMAND ON ENGINES 2 & 3
VERIFY AURAL WARNING ANNUNCIATION
SELECT IDLE THRUST COMMAND ON ENGINES 2 & 3
VERIFY AURAL WARNING CEASES

CONFIGURE EMERGENCY BRAKING SYSTEM
SELECT REJECTED TAKEOFF BRAKING
VERIFY ACTIVATED STATUS ANNUNCIATION

CONFIGURE FLIGHT MANAGEMENT SYSTEM (FMS)
VERIFY AIRCRAFT MODEL
VERIFY ENGINE TYPE
VERIFY OPERATING SYSTEM
VERIFY DATABASE EFFECTIVITY
SELECT PERFORMANCE FACTOR DEVIATION AS REQUIRED
INDENTIFY FLIGHT NUMBER
INITIALIZE WEATHER DATA: TEMPERATURE, WIND
INITIALIZE FUEL DATA: TOTAL, BALLAST, DUMP, & TYPE
INITIALIZE WEIGHT DATA: BLOCK, TOGW, TOCG, ZFWCG & ZFW
SELECT FLIGHT ORIGIN/DESTINATION
SELECT ALTERNATE DESTINATION
SELECT CRUISE ALTITUDE(S)
SELECT TIME/FUEL COST INDEX
SELECT ROUTE, SID, STAR???
COMPUTE FLIGHT PATH TIME & DISTANCE PREDICTIONS
SELECT FLEX TAKEOFF THRUST RATING

CONFIGURE NAVIGATION RADIO SYSTEM
SELECT RECEIVER
SELECT NAVIGATIONAL FIX
SELECT RECEIVER CHANNEL
REPEAT UNTIL ALL CHANNELS SELECTED
REPEAT UNTIL ALL NAV RADIOS SELECTED

INSPECT SHIPS PAPERS
VERIFY COMPLETE SHIP'S PAPERS ONBOARD

VERIFY FUEL QUANTITY
COMPUTE WEIGHT OF FUEL LOADED
ADD VALUE TO PRIOR FUEL WEIGHT
COMPARE TOTAL TO INSTRUMENT INDICATIONS
VERIFY DIFFERENCE WITHIN TOLERANCE
COMPARE TOTAL TO FLIGHT PLAN REQUIREMENTS
VERIFY DIFFERENCE WITHIN TOLERANCE

VERIFY WEIGHT AND BALANCE DATA
VERIFY TOGW
VERIFY TOCG

VERIFY FLIGHT MANAGEMENT SYSTEM DATA
VERIFY PLANNED FLIGHT ROUTE
VERIFY FLEX TEMPERATURE AS REQUIRED
VERIFY TAKEOFF SPEEDS
VERIFY REQUIRED TAKEOFF LIFT AUGMENTATION

CONFIGURE LIFT AUGMENTATION SYSTEM
SELECT TAKEOFF LIFT AUGMENTATION COMMAND (dial-a-flap)

CONFIGURE FLIGHT GUIDANCE SYSTEMS

SELECT TARGET SPEED UNITS (mach/ias)
SELECT (designate?) TARGET SPEED COMMAND
SELECT NAVIGATION MODE (heading/track)
SELECT NAVIGATION HEADING OR TRACK COMMAND
SELECT AIRSPEED, STALL & BUFFET MARGINS BANK ANGLE LIMITS
SELECT ALTITUDE UNITS (feet/meters)
SELECT ATC CLEARED ALTITUDE COMMAND
SELECT PITCH CONTROL MODE (vertical speed/flight path angle)
SELECT VERTICAL SPEED OR FLAP PATH ANGLE COMMAND

CONFIGURE AIR CONDITIONING SYSTEM FOR ANTICIPATED PASSENGER DEMANDS
CONSIDER NUMBER OF PASSENGERS
SELECT PASSENGER AIR SUPPLY LOAD

VERIFY AIRCRAFT SYSTEMS CONFIGURED FOR ACTIVATION
ACCESS COCKPIT PREPARATION CHECKLIST
VERIFY AIRCRAFT SYSTEMS STATUS ACCEPTABLE FOR FLIGHT
VERIFY HYDRAULIC SYSTEM TESTED/CONFIGURED FOR TAKEOFF
VERIFY FUEL SYSTEM TESTED/CONFIGURED FOR TAKEOFF
VERIFY EXTERIOR LIGHTS ACTIVATED AS REQUIRED FOR TAKEOFF
VERIFY EVACUATION WARNING SYSTEM ARMED
VERIFY EMERGENCY OXYGEN SYSTEM TESTED/CONFIGURED FOR 100% O2
VERIFY NO MANUAL FLT CONTROL TRIM SYSTEM INPUT COMMNDS EXIST
VERIFY MAIN FUEL VALVES CLOSED
VERIFY FLT CONTROL CONFIGURATION TAKEOFF WARNING SYSTEM TESTED
VERIFY LANDING GEAR EMERGENCY LOCKING PROVISIONS AVAILABLE
VERIFY FLIGHT MANAGEMENT SYSTEM CONFIGURED FOR TAKEOFF
VERIFY LIFT AUGMENTATION SYSTEM CONFIGURED FOR TAKEOFF
VERIFY FLIGHT GUIDANCE SYSTEM CONFIGURED FOR TAKEOFF
VERIFY INERTIAL REFERENCE SYSTEM FULLY ALIGNED
STOW COCKPIT PREPARATION CHECKLIST

PREVENT UNAUTHORIZED CABIN ENTRY/EXIT
DIRECT CABIN CREW TO SECURE ENTRY DOORS
RECEIVE CABIN REPORT OF DOORS SECURED
VERIFY NO OPEN DOOR WARNINGS ANNUNCIATED

PROVIDE EMERGENCY EVACUATION CAPABILITY
DIRECT CABIN CREW TO ARM EVACUATION SLIDES
RECEIVE REPORT OF SLIDES ARMED

PREVENT UNATHORIZED COCKPIT ENTRY
CLOSE/LOCK COCKPIT ENTRY DOORS
CLOSE/LOCK COCKPIT WINDOWS

VERIFY AIRCRAFT MOVEMENT PREVENTED
VERIFY PARKING BRAKE SYSTEM ENGAGED

POSITION OPERATOR FOR OPTIMUM VIEWING (design eye)
MODIFY SEAT VERTICAL POSITION
MODIFY SEAT HORIZONTAL POSITION

POSITION YAW CONTROL FOR FULL TRAVEL
MODIFY RUDDER PEDAL POSITION

PROTECT MOVEMENT INDUCED PERSONNEL INJURY
ENGAGE PERSONNEL RESTRAINT SYSTEM (seat belts)

1.1.1.3 SEGMENT: SYSTEMS ACTIVATION

SEAT BELTS FASTENED

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTYLINE

COMMUNICATE WITH LA GROUND CONTROL
REQUEST ENGINE START CLEARANCE
RECEIVE ENGINE START CLEARANCE
ACKNOWLEDGE CLEARANCE RECEIPT

COMMUNICATE WITH GROUND PERSONNEL
- DIRECT GROUND CREW TO STAND CLEAR FOR ENGINE START
- RECEIVE GROUND CREW ACKNOWLEDGEMENT OF SAFETY CLEARANCE

PROVIDE ANTI-COLLISION WARNING TO OTHER AIRCRAFT
- ACTIVATE BEACON LIGHTS

PROVIDE IGNITION SOURCE FOR COMBUSTION
- VERIFY SINGLE IGNITION SOURCE SELECTION NOT PREVENTED
- SELECT DESIRED IGNITION SOURCE

PROVIDE FUEL SOURCE FOR COMBUSTION
- ACTIVATE ALL FUEL FEED PUMPS

PROVIDE AIR SUPPLY FOR AIR TURBINE STARTER
- OPEN AUXILIARY POWER SYSTEM AIR SUPPLY VALVE

PERMIT CROSS FEED BETWEEN ENGINE AIR INPUT LINES
- OPEN AIR DISTRIBUTION ISOLATION VALVES

PREVENT OUTPUT AIR FLOW TO AIR CONDITIONING SYSTEM
- CLOSE ALL AIR CONDITIONING SUPPLY VALVES

VERIFY AIRCRAFT PREPARED FOR PROPULSION SYSTEMS ACTIVATION
- ACCESS BEFORE STARTING ENGINES CHECKLIST
- VERIFY PERSONNEL RESTRAINT SYSTEM ENGAGED
- VERIFY AIRCRAFT DOORS/WINDOWS CLOSED/LOCKED
- VERIFY AIRCRAFT PARKING BRAKE SYSTEM ENGAGED
- VERIFY AIRCRAFT BEACON LIGHTS ACTIVATED
- VERIFY ENGINE IGNITION SOURCE SELECTED
- VERIFY FUEL FEED PUMPS ACTIVATED
- VERIFY AIR DISTRIBUTION ISOLATION VALVES OPEN
- VERIFY AIR CONDITIONING SUPPLY VALVES CLOSED
- VERIFY AIR SUPPLY PRESSURE NORMAL
- VERIFY ENGINE THRUST COMMANDED TO IDLE
- STOW BEFORE STARTING ENGINES CHECKLIST

ACTIVATE PROPULSION SYSYTEM
- SELECT ENGINE ACTIVATION ORDER
  - REVIEW FLIGHT MANUAL
  - REVIEW TERMINAL PROCEDURES
- ACTIVATE FIRST ENGINE
  - PROVIDE AIR DRIVEN ENGINE STARTING TORQUE
    - OPEN ENGINE STARTER VALVE
  - VERIFY AIR SUPPLY REMAINS ADEQUATE FOR ENGINE START
    - MONITOR STARTER AIR SUPPLY PRESSURE
  - VERIFY ENGINE SPEED ADEQUATE FOR FUEL/IGNITION
    - MONITOR ENG HI PRESS COMPRESSOR ROTATION SPEED (15%)
  - PROVIDE FUEL TO ENGINE
    - OPEN ENGINE FUEL FEED VALVE
  - PROVIDE IGNITION SPARK TO ENGINE
    - ACTIVATE IGNITION EXCITER
  - VERIFY ENGINE START TIME LIMIT NOT EXCEEDED
    - INITIATE ELAPSE TIME MEASUREMENT
    - MONITOR EXHAUST GAS TEMPERATURE RISE & PEAK TIMES
    - TERMINATE ELAPSE TIME MEASUREMENT
  - VERIFY FUEL FLOW ADEQUATE
    - MONITOR FUEL FLOW
  - VERIFY FUEL IGNITION OCCURRING
    - MONITOR EXHAUST GAS TEMPERATURE
  - VERIFY ADEQUATE ENGINE LUBRICATION OCCURRING
    - MONITOR ENGINE OIL PRESSURE
  - VERIFY ENGINE SPEED SELF-SUSTAINING
    - MONITOR ENG HI PRESS COMPRESSOR ROTATION SPEED (45%)
  - ELIMINATE AIR DRIVEN ENGINE STARTING TORQUE
    - CLOSE ENGINE STARTER VALVE
  - VERIFY ENGINE PERFORMANCE STABILIZED
    - MONITOR ENG HI PRESS COMPRESSOR ROTATION SPEED (65%)
    - MONITOR EXHAUST GAS TEMPERATURE (normal)

MONITOR ENGINE OIL PRESSURE (normal)
REPEAT FUNCTIONAL SEQUENCE FOR EACH ENGINE TO BE STARTED

PREVENT AND/OR ELIMINATE ICE BUILD-UP ON AIRCRAFT
EVALUATE CURRENT ANTI-ICING REQUIREMENTS
MONITOR OUTSIDE TEMPERATURE & HUMIDITY
MONITOR ICE BUILD-UP ON AIRCRAFT
EVALUATE FUTURE ANTI-ICING REQUIREMENTS
REVIEW WEATHER FORECAST
REVIEW ROUTE
PROVIDE HEAT TO ENGINE & CONTROL SURFACES AS REQUIRED
OPEN APPROPRIATE BLEED AIR ANTI-ICE VALVES
PROVIDE HEAT TO WINDSHIELD AS REQUIRED
CLOSE APPROPRIATE ELECTRICAL SWITCH
PROVIDE HEAT TO PRESSURE, ATTITUDE & TEMPERATURE SENSORS
CLOSE APPROPRIATE ELECTRICAL SWITCH

CONFIGURE LONGITUDINAL CONTROL SYSTEM TRIM FOR TAKEOFF
COMPUTE PITCH TRIM REQUIREMENT
SELECT PITCH TRIM LEVEL

CONFIGURE AIR SYSTEM FOR TAXI OPERATIONS
PREVENT CROSS FEED BETWEEN ENGINE PNEUMATIC LINES
CLOSE ALL PNEUMATIC ISOLATION VALVES
PROVIDE ENGINE AIR FLOW TO AIR CONDITIONING SYSTEM
OPEN ALL PACK FLOW VALVES
ELIMINATE AUXILIARY AIR SUPPLY
CLOSE APU AIR SUPPLY VALVE

CONFIGURE ELECTRICAL POWER SYSTEM FOR FLIGHT OPERATIONS
VERIFY ENGINE ELECTRICAL POWER GENERATION
VERIFY ALL ENGINE DRIVEN GENERATORS ONLINE
VERIFY AC POWER DISTRIBUTION
VERIFY ALL AC BUSES POWERED
VERIFY ALL AC BUS TIES CLOSED
VERIFY DC POWER DISTRIBUTION
VERIFY ALL DC BUSES POWERED
VERIFY ALL DC BUS TIES CLOSED
ELIMINATE AUXILIARY ELECTRICAL POWER
OPEN AUXILIARY ELECTRICAL POWER BUS
STOP AUXILIARY POWER UNIT (apu)
STOP APU FUEL PUMP

CONFIGURE HYDRAULIC POWER SYSTEM FOR TAXI OPERATIONS
VERIFY SECONDARY SYSTEM OPERABILITY
VERIFY SECONDARY ENGINE DRIVEN PUMPS ACTIVATED
VERIFY PRIMARY ENGINE DRIVEN PUMPS DEACTIVATED
VERIFY SYSTEM PRESSURE NORMAL
VERIFY NO FAULT INDICATIONS ARE PRESENT
VERIFY PRIMARY SYSTEM OPERABILITY
ACTIVATE PRIMARY ENGINE DRIVEN PUMPS
DEACTIVATE/ARM SECONDARY ENGINE DRIVEN PUMPS
VERIFY SYSTEM PRESSURE NORMAL
VERIFY NO FAULT INDICATIONS ARE PRESENT

VERIFY AIRCRAFT MOVEMENT SAFETY
ELIMINATE EXTERNAL IMPEDIMENT TO AIRCRAFT MOVEMENT
DIRECT GROUND CREW TO REMOVE CHOCKS
RECEIVE GROUND CREW REPORT
PREVENT INJURY TO GROUND CREW AND DAMAGE TO EQUIP/AIRCRAFT
DIRECT GROUND CREW TO REMOVE EXTERNAL EQUIPMENT
DIRECT GROUND CREW TO STAND CLEAR OF AIRCRAFT
RECEIVE GROUND CREW REPORT
PREVENT INJURY TO CABIN CREW AND PASSENGERS
DIRECT CABIN CREW TO ENSURE PASSENGERS SEATED/BELTED
DIRECT CABIN CREW TO ENSURE CARRY-ON LUGGAGE SECURED
DIRECT CABIN CREW TO ASSUME TAXI POSITIONS
RECEIVE CABIN CREW REPORT

VERIFY SYSTEMS PROPERLY CONFIGURED FOR AIRCRAFT MOVEMENT
ACCESSS AFTER ENGINE START CHECKLIST
VERIFY ANTI-ICING SET FOR EXISTING/ANTICIPATED WEATHER
VERIFY LONGITUDINAL TRIM SET FOR TAKEOFF
VERIFY AIRCRAFT MOVEMENT SAFETY REQUIREMENTS SATISFIED
VERIFY HYDRAULIC POWER SYSTEM CONFIGURED FOR TAXI
VERIFY AIR SUPPLY SYSTEM CONFIGURED FOR TAXI
STOW AFTER ENGINE START CHECKLIST

1.2 PERIOD: DEPARTURE

1.2.1 PHASE: TAXI OUT

1.2.1.1 SEGMENT: GATE DISENGAGEMENT

AFTER START CHECKLIST COMPLETED

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITIES
MONITOR PARTYLINE

COMMUNICATE WITH LA GROUND CONTROL
REQUEST BACKUP CLEARANCE
RECEIVE BACKUP CLEARANCE
ACKNOWLEDGE BACKUP CLEARANCE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

CONFIGURE GROUND BRAKING SYSTEMS
DISENGAGE PARKING BRAKE
DISENGAGE MANEUVERING BRAKE (toe brakes)

STEER AIRCRAFT AWAY FROM GATE
SELECT STEERING OPTIONS (nosewheel/rudder pedals)
COMMAND STEERING DIRECTION/MAGNITUDE
MONITOR AIRCRAFT INDICATED/COMMANDED POSITION
EVALUATE MOVEMENT PROGRESS
MODIFY STEERING COMMANDS AS REQUIRED

ACCELERATE TO BACKING SPEED
SELECT SPEED INCREASE TARGET
COMMAND REVERSE THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

BACKING SPEED ATTAINED

MAINTAIN BACKING SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

DECELERATION CUE

DECELERATE TO A STOP
SELECT SPEED DECREASE TARGET
COMMAND REVERSE THRUST DECREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONFIGURE GROUND BRAKE SYSTEM
ENGAGE GROUND MANEUVERING BRAKE

1.2.1.2 SEGMENT: DEPARTURE TAXI

AIRCRAFT STOPPED

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTYLINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

COMMUNICATE WITH LA GROUND CONTROL
REPORT AIRCRAFT CLEAR OF GATE
REQUEST TAXI CLEARANCE
RECEIVE TAXI CLEARANCE
ACKNOWLEDGE TAXI CLEARANCE

END TAXI CLEARANCE ACKNOWLEDGE

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

CONFIGURE GROUND BRAKE SYSTEM
DISENGAGE GROUND MANEUVERING BRAKE

ACCELERATE TO TAXI SPEED
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

TURN 90 DEGREES LEFT
SELECT STEERING OPTION
COMMAND LEFT TURN
MONITOR INDICATED/COMMANDED POSITION
EVALUATE TURN PROGRESS
MODIFY STEERING COMMAND AS REQUIRED

ON COURSE

MAINTAIN HEADING
MONITOR INDICATED/COMMANDED POSITION
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY STEERING COMMANDS AS REQUIRED

TAXI SPEED ATTAINED

MAINTAIN TAXI SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

VERIFY AIRCRAFT PREPARED FOR LINE-UP
ACCESS TAXI CHECKLIST
EXTEND FLAPS TO 25 DEGREES (trailing edge lift)
EXTEND SLATS (leading edge lift)
ARM SPOILERS
ARM EMERGENCY BRAKING SYSTEM
VERIFY FLIGHT CONTROL SYSTEM OPERATION (PITCH/ROLL/YAW)
CONFIGURE ELECTRONIC DISPLAY SYSTEM
STOW TAXI CHECKLIST

COMMUNICATE WITH CABIN
BRIEF CREW/PASSENGERS
RECEIVE CABIN REPORT

DECELERATION CUE

DECELERATE TO A STOP
SELECT SPEED DECREASE TARGET
COMMAND FORWARD THRUST DECREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONFIGURE GROUND BRAKE SYSTEM
ENGAGE GROUND MANEUVERING BRAKE

1.2.1.3 SEGMENT: DEP RWY PRE-POSN HLDNG

AIRCRAFT STOPPED

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTYLINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

COMMUNICATE WITH LA GROUND CONTROL
REPORT ARRIVAL AT RUNWAY THRESHOLD

VERIFY AIRCRAFT CONFIGURED FOR TAKEOFF
ACCESS BEFORE TAKEOFF CHECKLIST
VERIFY ANTI-ICE SYSTEM SET AS REQUIRED
ACTIVATE MAIN LANDING LIGHTS
ACTIVATE NOSE LANDING/TAXI LIGHTS
ACTIVATE HIGH INTENSITY RECOGNITION LIGHTS
STOW BEFORE TAKEOFF CHECKLIST

COMMUNICATE WITH CABIN
DIRECT CREW TO ASSUME TAKEOFF STATIONS
RECEIVE CABIN REPORT

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE LA TOWER

COMMUNICATE WITH LA TOWER
REQUEST POSITION & HOLDING CLEARANCE
RECEIVE POSITION & HOLDING CLEARANCE
ACKNOWLEDGE POSITION & HOLDING CLEARANCE

1.2.1.4 SEGMENT: DEP RNWY POSN HLDNG

END POSITION & HOLD
CLEARANCE ACKNOWLEDGE

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

CONFIGURE GROUND BRAKE SYSTEM
DISENGAGE GROUND MANEUVERING BRAKE

ACCELERATE TO TAXI SPEED
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

TURN 90 DEGREES RIGHT
SELECT STEERING OPTIONS
COMMAND RIGHT TURN
MONITOR AIRCRAFT INDICATED/COMMANDED POSITION
EVALUATE TURN PROGRESS
MODIFY STEERING COMMANDS AS REQUIRED

ON COURSE

MAINTAIN HEADING
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY STEERING COMMANDS AS REQUIRED

TAXI SPEED ATTAINED

MAINTAIN TAXI SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

DECELERATION CUE

DECELERATE TO A STOP
SELECT SPEED DECREASE TARGET
COMMAND FORWARD THRUST DECREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONFIGURE GROUND BRAKE SYSTEM
ENGAGE GROUND MANEUVERING BRAKE

AIRCRAFT STOPPED

COMMUNICATE WITH LA TOWER
REPORT ARRIVAL AT TAKEOFF POSITION
REQUEST TAKEOFF CLEARANCE
RECEIVE TAKEOFF CLEARANCE
ACKNOWLEDGE TAKEOFF CLEARANCE

1.2.2 PHASE: TAKEOFF

1.2.2.1 SEGMENT: TAKEOFF GROUND ROLL

END TAKEOFF CLEARANCE ACKNOWLEDGEMENT

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

CONFIGURE GROUND BRAKE SYSTEM
ENGAGE MANEUVERING BRAKE

MAINTAIN AWARENESS OF FLIGHT PLAN
INITIATE ELAPSED FLIGHT TIME MEASUREMENT

ACCELERATE TO 80 KTS
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN HEADING (RUNWAY CENTERLINE)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY STEERING COMMANDS AS REQUIRED

80 KTS ATTAINED

VERIFY AIRSPEED INDICATION ACCURACY
COMPARE INDICATIONS

ACCELERATE TO ROTATION VELOCITY (Vr)
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

TAKEOFF ABORT SPEED ATTAINED

1.2.2.2 SEGMENT: LIFTOFF

ROTATION SPEED ATTAINED

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

ROTATE AIRCRAFT TO TAKEOFF ATTITUDE
SELECT NOSE UP ATTITUDE TARGET
COMMAND PITCH UP
MONITOR INDICATED/COMMANDED ATTITUDE
EVALUATE ATTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN HEADING
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

ACCELERATE TO CLIMB SPEED (V2 + 10)
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

ASCEND TO 50 FT AGL
SELECT ALTITUDE INCREASE TARGET
COMMAND PITCH UP ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

CLIMB SPEED ATTAINED

MAINTAIN CLIMB VELOCITY
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

STABLE FLIGHT ATTAINED

CONFIGURE LANDING GEAR SYSTEM
RAISE LANDING GEAR

CONFIGURE DRAG AUGMENTATION SYSTEM
DISARM GROUND SPOILERS

1.2.2.3 SEGMENT: INITIAL ASCENT

ARRIVE AT 50 FT AGL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING

MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN CLIMB SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

ASCEND TO 1500 FT MSL
SELECT ALTITUDE INCREASE TARGET
COMMAND PITCH UP ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

COMMUNICATE WITH LA TOWER
RECEIVE NEW VHF COMM FREQ ASSIGNMENT
ACKNOWLEDGE COMM FREQ ASSIGNMENT

END FREQUENCY CHANGE ACKNOWLEDGE

CONFIGURE VHF COMMUNICATION SYSTEM
TUNE LA DEPARTURE CONTROL

COMMUNICATE WITH LA DEPARTURE CONTROL
REPORT AIRBORNE STATUS
RECEIVE NEW ALTITUDE CLEARANCE
ACKNOWLEDGE NEW ALTITUDE CLEARANCE

END ALTITUDE CHANGE ACKNOWLEDGE

ASCEND TO 13,000 FT MSL
SELECT ALTITUDE INCREASE TARGET
COMMAND PITCH UP ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

1.2.2.4 SEGMENT: TRANSITION/ACCELERATION

ARRIVE AT 1500 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

PROVIDE FLIGHT GUIDANCE AND CONTROL INFORMATION
ACTIVATE FLIGHT GUIDANCE & CONTROL SYSTEM

MAINTAIN AIRCRAFT HEADING (at 249 deg)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 13,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN CLIMB SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

CROSS LAX VOR 300 RADIAL

ACCELERATE TO VMM (250 KNOTS)
- SELECT SPEED INCREASE TARGET
- COMMAND FORWARD THRUST INCREASE
- MONITOR INDICATED/COMMANDED SPEED
- EVALUATE SPEED INCREASE PROGRESS
- MODIFY THRUST COMMANDS AS REQUIRED

FLAP RETRACT SPEED ATTAINED (176 KTS)

CONFIGURE TRAILING EDGE LIFT AUGMENTATION SYSTEM
- RETRACT FLAPS

SLAT RETRACTION SPEED ATTAINED (214 KTS)

CONFIGURE LEADING EDGE LIFT AUGMENTATION SYSTEM
- RETRACT SLATS

1.2.2.5 SEGMENT: ASCENT TO 3,000 FT MSL

Vmm ATTAINED (250 KTS)

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
- MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
- MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
- MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
- MONITOR FLIGHT PROGRESS

PREVENT AIRCRAFT FROM EXCEEDING NORMAL BANK ANGLES
- ACTIVATE BANK ANGLE LIMITING SYSTEM

MAINTAIN AIRCRAFT HEADING
- MONITOR INDICATED/COMMANDED HEADING
- EVALUATE HEADING CHANGE REQUIREMENTS
- MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 13,000 FT MSL)
- MONITOR INDICATED/COMMANDED ALTITUDE
- EVALUATE ALTITUDE INCREASE PROGRESS
- MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (250 KTS)
- MONITOR INDICATED/COMMANDED AIRSPEED
- EVALUATE SPEED CHANGE REQUIREMENTS
- MODIFY THRUST COMMANDS AS REQUIRED

ARRIVE AT 3,000 FT MSL

1.2.3 PHASE: CLIMB

1.2.3.1 SEGMENT: ASCENT TO 10,000 FT MSL

ARRIVE AT 3,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
- MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
- MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
- MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
- MONITOR FLIGHT PROGRESS

CONFIGURE AUTO THROTTLE SYSTEM
    ACTIVATE AUTO THROTTLE

MAINTAIN AIRCRAFT SPEED (250 KTS)
    MONITOR INDICATED/COMMANDED AIRSPEED
    EVALUATE SPEED CHANGE REQUIREMENTS
    MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 13,000 FT MSL)
    MONITOR INDICATED/COMMANDED ALTITUDE
    EVALUATE ALTITUDE INCREASE PROGRESS
    MODIFY PITCH COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING (114 degrees)
    SELECT ROLL RATES
    MONITOR FOR ROLL IN CUE
    COMMAND LEFT ROLL IN
    MONITOR INDICATED/COMMANDED ROLL RATE
    EVALUATE TURN PROGRESS
    MODIFY ROLL RATE AS REQUIRED
    MONITOR FOR ROLL OUT CUE
    COMMAND RIGHT ROLL OUT
    EVALUATE RECOVERY PROGRESS
    MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (at 114 degrees)
    MONITOR INDICATED/COMMANDED HEADING
    EVALUATE HEADING CHANGE REQUIREMENTS
    MODIFY ROLL/YAW COMMANDS AS REQUIRED

VERIFY AIRCRAFT CONFIGURED FOR CLIMB
    ACCESS AFTER TAKEOFF CHECKLIST
    VERIFY LANDING GEAR RAISED
    VERIFY FLAPS RETRACTED
    VERIFY SLATS RETRACTED
    VERIFY SPOILERS DISARMED
    VERIFY EXTERNAL LIGHTS SET AS REQUIRED
    DEACTIVATE NO SMOKING/SEAT BELT WARNING ANNUNCIATION
    STOW AFTER TAKEOFF CHECKLIST

CONFIGURE PNEUMATICS SYSTEM FOR CLIMB

CONFIGURE AIR CONDITIONING SYSTEM FOR CLIMB

CONFIGURE HYDRAULIC SYSTEM FOR CLIMB

CONFIGURE FUEL SYSTEM FOR CLIMB

CONFIGURE PRESSURIZATION SYSTEM FOR CLIMB

COMMUNICATE WITH LA DEPARTURE CONTROL
    RECEIVE NEW ALTITUDE CLEARANCE
    ACKNOWLEDGE NEW ALTITUDE CLEARANCE

END ALTITUDE CHANGE ACKNOWLEDGE

ASCEND TO 18,000 FT MSL
    SELECT ALTITUDE INCREASE TARGET
    COMMAND PITCH UP ATTITUDE
    MONITOR INDICATED/COMMANDED ALTITUDE
    EVALUATE ALTITUDE INCREASE PROGRESS
    MODIFY PITCH COMMANDS AS REQUIRED
COMMUNICATE WITH CABIN
    BRIEF PASSENGERS ON FLIGHT PLAN

1.2.3.2 SEGMENT: ASCENT TO 18,000 FT MSL

ARRIVE AT 10,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY

MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

ACCELERATE TO CRUISE SPEED
SELECT SPEED INCREASE TARGET
COMMAND FORWARD THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 18,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING (040 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND LEFT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND RIGHT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (SLI VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED WITHIN PRESELECTED LIMITS
ACTIVATE FLIGHT MANAGEMENT SYSTEM SPEED MODE

CONFIGURE EXTERNAL LIGHTING SYSTEM
DEACTIVATE MAIN LANDING LIGHTS
DEACTIVATE NOSE LANDING LIGHTS
VERIFY HIGH INTENSITY RECOGNITION LIGHTS ACTIVATED

COMMUNICATE WITH LA DEPARURE CONTROL
RECEIVE NEW VHF COMM FREQUENCY
ACKNOWLEDGE NEW COMM FREQUENCY ASSIGNMENT

END FREQUENCY CHANGE ACKNOWLEDGE

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE LA CENTER

COMMUNICATE WITH LA CENTER
REPORT AIRCRAFT POSITION
RECEIVE NEW ALTITUDE CLEARANCE
ACKNOWLEDGE NEW ALTITUDE CLEARANCE

END ALTITUDE CHANGE ACKNOWLEDGE

ASCEND TO 23,000 FT MSL
SELECT ALTITUDE INCREASE TARGET
COMMAND PITCH UP ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

COMMUNICATE WITH LA CENTER
RECEIVE TRAFFIC ADVISORY

END TRAFFIC ADVISORY

VERIFY TRAFFIC LOCATION
SCAN DESIGNATED AREA
LOCATE TRAFFIC

COMMUNICATE WITH LA CENTER
REPORT TRAFFIC SIGHTING

1.2.3.3 SEGMENT: ASCENT TO WPNT SLI VORTAC

ARRIVE AT 18,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

CONFIGURE ALTIMETERS FOR LOCAL PRESSURE
SELECT BAROMETRIC PRESSURE (29.91 ins)

CONTINUE ACCELERATION TO CRUISE SPEED
MONITOR INDICATED/COMMANDED AIRSPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 23,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT HEADING (SLI VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.2.3.4 SEGMENT: ASCENT TO WPNT TRM VORTAC

CROSS SLI VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

CONTINUE ACCELERATION TO CRUISE SPEED
MONITOR INDICATED/COMMANDED AIRSPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 23,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

TURN RIGHT TO NEW HEADING (080 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND RIGHT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND LEFT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

MAINTAIN AIRCRAFT HEADING (TRM VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH LA CENTER
RECEIVE NEW VHF COMM FREQUENCY
ACKNOWLEDGE NEW COMM FREQUENCY ASSIGNMENT

END FREQUENCY CHANGE ACKNOWLEDGE

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE LA CENTER

COMMUNICATE WITH LA CENTER
REPORT AIRCRAFT POSITION
RECEIVE NEW ALTITUDE CLEARANCE
ACKNOWLEDGE NEW ALTITUDE CLEARANCE

END ALTITUDE CHANGE ACKNOWLEDGE

ASCEND TO 33,000 FT MSL
SELECT ALTITUDE INCREASE TARGET
COMMAND PITCH UP ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

CROSS TRM VORTAC

1.2.3.5 SEGMENT: ASCENT TO WPNT TNP VORTAC

CROSS TRM VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

CONTINUE ACCELERATION TO CRUISE SPEED
MONITOR INDICATED/COMMANDED AIRSPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING (037 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND LEFT ROLL IN

MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND RIGHT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (TNP VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH LA CENTER
RECEIVE TRAFFIC ADVISORY

END TRAFFIC ADVISORY

VERIFY TRAFFIC LOCATION
SCAN DESIGNATED AREA
LOCATE TRAFFIC

COMMUNICATE WITH LA CENTER
REPORT TRAFFIC SIGHTING

CROSSING TNP VORTAC

1.2.3.6 SEGMENT: ASCENT TO CRUISE ALTITUDE

CROSS TNP VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

TURN RIGHT TO NEW HEADING (060 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND RIGHT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND LEFT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (DRK VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONTINUE ACCELERATION TO CRUISE SPEED
MONITOR INDICATED/COMMANDED AIRSPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

CRUISE SPEED ATTAINED

MAINTAIN CRUISE SPEED
MONITOR INDICATED/COMMANDED AIRSPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT ASCENT (to 33,000 FT MSL)

MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

COMMUNICATE WITH LA CENTER
RECEIVE TRAFFIC ADVISORY

END TRAFFIC ADVISORY

VERIFY TRAFFIC LOCATION
SCAN DESIGNATED AREA
LOCATE TRAFFIC

COMMUNICATE WITH LA CENTER
REPORT TRAFFIC SIGHTING

1.3 PERIOD: EN ROUTE

1.3.1 PHASE: CRUISE

1.3.1.1 SEGMENT: FLIGHT TO WPNT DRK VORTAC

ARRIVE AT 33,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT HEADING (DRK VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH LA CENTER
RECEIVE NEW VHF COMM FREQUENCY ASSIGNMENT
ACKNOWLEDGE NEW COMM FREQUENCY ASSIGNMENT

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE ABQ CENTER

COMMUNICATE WITH ABQ CENTER
REPORT AIRCRAFT POSITION
RECEIVE IDENTIFICATION REQUEST
TRANSMIT AIRCRAFT IDENTITY (BY TRANSPONDER CODE)

CROSS DRK VORTAC

1.3.1.2 SEGMENT: FLIGHT TO WPNT GUP VORTAC

CROSS DRK VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY

MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN RIGHT TO NEW HEADING (061 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND RIGHT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND LEFT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (GUP VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH ABQ CENTER
RECEIVE NEW COMM CONTROL CENTER ASSIGNMENT
ACKNOWLEDGE NEW COMM CONTROL CENTER ASSIGNMENT

END COMM FREQUENCY CHANGE ACKNOWLEDGE

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE CLEVELAND CENTER

COMMUNICATE WITH CLEVELAND CENTER
REPORT AIRCRAFT POSITION

1.3.1.3 SEGMENT: FLIGHT TO WPNT CIM VORTAC

CROSS GUP VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING (055 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND LEFT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND RIGHT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (CIM VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.4 SEGMENT: FLIGHT TO WPNT LBL VORTAC

CROSS CIM VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND LEFT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND RIGHT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (LBL VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.5 SEGMENT: FLIGHT TO WPNT ICT VORTAC

CROSS LBL VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND LEFT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND RIGHT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (ICT VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.6 SEGMENT: FLIGHT TO WPNT BUM VORTAC

CROSS ICT VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN RIGHT TO NEW HEADING
SELECT ROLL RATES

MONITOR FOR ROLL IN CUE
COMMAND RIGHT ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND LEFT ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (BUM VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.7 SEGMENT: FLIGHT TO WPNT STL VORTAC

CROSS BUM VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (STL VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.8 SEGMENT: FLIGHT TO WPNT VHP VORTAC

CROSS STL VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (VHP VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.9 SEGMENT: FLIGHT TO WPNT CREEP INTERSECTION

CROSS VHP VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (CREEP INTERSECTION)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.10 SEGMENT: FLIGHT TO WPNT AIR VORTAC

CROSS CREEP INTERSECTION

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (AIR VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.11 SEGMENT: FLIGHT TO WPNT BOGGE INTERSECTION

CROSS AIR VORTAC

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
    MONITOR INDICATED/COMMANDED SPEED
    EVALUATE SPEED CHANGE REQUIREMENTS
    MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
    SELECT ROLL RATES
    MONITOR FOR ROLL IN CUE
    COMMAND ROLL IN
    MONITOR INDICATED/COMMANDED ROLL RATE
    EVALUATE TURN PROGRESS
    MODIFY ROLL RATE AS REQUIRED
    MONITOR FOR ROLL OUT CUE
    COMMAND ROLL OUT
    EVALUATE RECOVERY PROGRESS
    MODIFY ROLL RATE AS REQUIRED

MAINTAIN AIRCRAFT HEADING (BOGGE INTERSECTION)
    MONITOR INDICATED/COMMANDED HEADING
    EVALUATE HEADING CHANGE REQUIREMENTS
    MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.3.1.12 SEGMENT: FLIGHT TO TOP OF DESCENT

CROSS BOGGE INTERSECTION

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
    MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
    MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
    MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
    MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT ALTITUDE (at 33,000 FT MSL)
    MONITOR INDICATED/COMMANDED ALTITUDE
    EVALUATE ALTITUDE CHANGE REQUIREMENTS
    MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at cruise speed)
    MONITOR INDICATED/COMMANDED SPEED
    EVALUATE SPEED CHANGE REQUIREMENTS
    MODIFY THRUST COMMANDS AS REQUIRED

TURN TO NEW HEADING
    SELECT ROLL RATES
    MONITOR FOR ROLL IN CUE
    COMMAND ROLL IN
    MONITOR INDICATED/COMMANDED ROLL RATE
    EVALUATE TURN PROGRESS
    MODIFY ROLL RATE AS REQUIRED
    MONITOR FOR ROLL OUT CUE
    COMMAND ROLL OUT
    EVALUATE RECOVERY PROGRESS
    MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (COPES INTERSECTION)
    MONITOR INDICATED/COMMANDED HEADING
    EVALUATE HEADING CHANGE REQUIREMENTS
    MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH CLEVELAND CENTER
    RECEIVE NEW COMM CONTROL CENTER ASSIGNMENT (NY)
    ACKNOWLEDGE NEW COMM CONTROL CENTER ASSIGNMENT

END COMM FREQUENCY CHANGE ACKNOWLEDGE

CONFIGURE VHF COMMUNICATIONS SYSTEM
TUNE NEW YORK CENTER

COMMUNICATE WITH NEW YORK CENTER
REPORT AIRCRAFT POSITION/STATUS
RECEIVE DESCENT CLEARANCE
ACKNOWLEDGE DESCENT CLEARANCE
TRANSMIT AIRCRAFT IDENTITY (BY TRANSPONDER CODE)

ARRIVE AT DECELERATION POINT

DECELERATE TO DESCENT SPEED
SELECT SPEED DECREASE TARGET
COMMAND FORWARD THRUST DECREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

1.4 PERIOD: ARRIVAL

1.4.1 PHASE: DESCENT

1.4.1.1 SEGMENT: DESCENT TO 25,000 FT MSL

ARRIVE AT TOP OF DESCENT

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING (COPES INTERSECTION)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

DESCEND TO 25,000 FT MSL
SELECT ALTITUDE DECREASE TARGET
SELECT PITCH DOWN ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

CONTINUE DECELERATION TO DESCENT SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

DESCENT SPEED (310 KTS) ATTAINED

MAINTAIN AIRCRAFT SPEED (at descent speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK CENTER
RECEIVE TRAFFIC ADVISORY

END TRAFFIC ADVISORY

VERIFY TRAFFIC LOCATION
SCAN DESIGNATED AREA
LOCATE TRAFFIC

COMMUNICATE WITH NEW YORK CENTER
REPORT TRAFFIC SIGHTING

1.4.1.2 SEGMENT: DESCENT TO 18,000 FT

ARRIVE at 25,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING (COPES INTERSECTION)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at 310 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN ALTITUDE (at 25,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK CENTER
RECEIVE NEW ALTITUDE CLEARANCE
ACKNOWLEDGE NEW ALTITUDE CLEARANCE

END ALTITUDE CHANGE ACKNOWLEDGE

DESCEND TO 13,000 FT MSL
SELECT ALTITUDE DECREASE TARGET
COMMAND PITCH DOWN ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

1.4.1.3 SEGMENT: DESCENT TO 13,000 FT MSL

ARRIVE AT 18,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT SPEED (at 310 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT HEADING (COPES INTERSECTION)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONTINUE AIRCRAFT DESCENT (to 13,000 FT MSL)
  MONITOR INDICATED/COMMANDED ALTITUDE
  EVALUATE ALTITUDE DECREASE PROGRESS
  MODIFY PITCH COMMANDS AS REQUIRED

CONFIGURE ALTIMETERS FOR LOCAL PRESSURE
  SELECT NEW BAROMETRIC SETTING

CONFIGURE NAVIGATION RADIO SYSTEM
  TUNE JFK ATIS

COMMUNICATE WITH JFK AIR TRAFFIC INFO SERVICE (ATIS)
  MONITOR JFK ATIS FOR PERTINENT INFO (Weather, Visibility, etc)
  RECORD BARO SETTING, VISIBILITY, CEILING, WINDS, ETC.

PREPARE FOR MISSED APPROACH
  SELECT MISSED APPROACH RUNWAY
  SELECT MISSED APPROACH SPEEDS

VERIFY AIRCRAFT CONFIGURED FOR APPROACH
  ACCESS DESCENT/APPROACH CHECKLIST
  VERIFY NORMAL APPROACH SPEEDS SELECTED
  SET ANTI-ICE SYSTEM AS REQUIRED
  SELECT DECISION HEIGHT (250FT)
  SET PASSENGER WARNING SYSTEM SET AS REQUIRED
  VERIFY ALTIMETERS SET FOR BAROMETRIC PRESSURE
  VERIFY RADIOS SET AS REQUIRED
  VERIFY ELECTRONIC DISPLAY SYSTEM SET AS REQUIRED
  CONFIGURE HYDRAULIC SYSTEM FOR DESCENT
  STOW DESCENT/APPROACH CHECKLIST

COMMUNICATE WITH CABIN
  BRIEF CREW ON APPROACH/LANDING PROCEDURES

1.4.1.4 SEGMENT: DESCENT TO 10,000 FT MSL

ARRIVE AT 13,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
  MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
  MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
  MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
  MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING (COPES INTERSECTION)
  MONITOR INDICATED/COMMANDED HEADING
  EVALUATE HEADING CHANGE REQUIREMENTS
  MODIFY ROLL/YAW COMMANDS AS REQUIRED

CROSS COPES INTERSECTION

TURN TO NEW HEADING
  SELECT ROLL RATES
  MONITOR FOR ROLL IN CUE
  COMMAND ROLL IN
  MONITOR INDICATED/COMMANDED ROLL RATE
  EVALUATE TURN PROGRESS
  MODIFY ROLL RATE AS REQUIRED
  MONITOR FOR ROLL OUT CUE
  COMMAND ROLL OUT
  EVALUATE RECOVERY PROGRESS
  MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (RBV VORTAC)
  MONITOR INDICATED/COMMANDED HEADING

EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT ALTITUDE (at 13,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at 310 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK CENTER
REPORT POSITION
RECEIVE COMM FREQUENCY CHANGE
ACKNOWLEDGE COMM FREQUENCY CHANGE

END COMM FREQ CHANGE ACKNOWLEDGE

CONFIGURE NAVIGATION RADIO SYSTEM
TUNE NEW YORK APPROACH

COMMUNICATE WITH NEW YORK APPROACH CONTROL
TRANSMIT AIRCRAFT IDENTITY (BY TRANSPONDER CODE)
RECEIVE APPROACH INSTRUCTIONS
ACKNOWLEDGE APPROACH INSTRUCTIONS

END APPROACH INSTRUCTIONS ACKNOWLEDGE

DESCEND TO 5,000 FT MSL
SELECT ALTITUDE DECREASE TARGET
COMMAND PITCH DOWN ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

DECELERATE AIRCRAFT (to 250 KTS)
SELECT SPEED DECREASE TARGET
COMMAND THRUST DECREASE LEVEL
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

1.4.1.5 SEGMENT: DESCENT TO 5,000 FT MSL

ARRIVE AT 10,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

CONTINUE AIRCRAFT DESCENT (to 5,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED
CONTINUE DECELERATION TO 250 KTS
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT HEADING (RBV VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONFIGURE EXTERNAL LIGHTING SYSTEM
ACTIVATE MAIN LANDING LIGHTS
ACTIVATE NOSE TAXI/LANDING LIGHTS
VERIFY HIGH INTENSITY RECOGNITION LIGHTS ACTIVATED
ACTIVATE WING LIGHTS

250 KTS ATTAINED

MAINTAIN AIRCRAFT SPEED (at 250 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

CROSS RBV VORTAC

TURN RIGHT TO NEW HEADING (077 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (COL VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

1.4.1.6 SEGMENT: DESCENT TO INTL APRCH FIX

ARRIVE AT 5,000 FT MSL

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING (COL VORTAC)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT ALTITUDE (at 5,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at 250 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK APPROACH
REPORT POSITION
RECEIVE APPROACH INSTRUCTIONS
ACKNOWLEDGE APPROACH INSTRUCTIONS

END APPROACH INSTRUCTIONS ACKNOWLEDGE

DESCEND TO 2,000 FT MSL
SELECT ALTITUDE DESCENT TARGET (2,000 FT MSL)
COMMAND PITCH DOWN ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE

EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

CROSS COL VORTAC

TURN RIGHT TO NEW HEADING (100 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (IAF)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK APPROACH
RECEIVE APPROACH INSTRUCTIONS
ACKNOWLEDGE APPROACH INSTRUCTIONS

END APPROACH INSTRUCTIONS ACKNOWLEDGE

DECELERATE AIRCRAFT (to 200 KTS)
SELECT SPEED DECREASE TARGET
COMMAND THRUST DECREASE LEVEL
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

200 KTS ATTAINED

MAINTAIN AIRCRAFT SPEED (at 200 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

ARRIVE AT 2000 FT MSL

MAINTAIN AIRCRAFT ALTITUDE (at 2,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

1.4.2 PHASE: APPROACH

1.4.2.1 SEGMENT: DESCENT TO INTRMD APRCH FIX

CROSS INITIAL APPROACH FIX (IAF)

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT SPEED (at 200 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT ALTITUDE (at 2,000 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

TURN LEFT TO NEW HEADING (048 degrees)
  SELECT ROLL RATES
  MONITOR FOR ROLL IN CUE
  COMMAND ROLL IN
  MONITOR INDICATED/COMMANDED ROLL RATE
  EVALUATE TURN PROGRESS
  MODIFY ROLL RATE AS REQUIRED
  MONITOR FOR ROLL OUT CUE
  COMMAND ROLL OUT
  EVALUATE RECOVERY PROGRESS
  MODIFY ROLL RATE AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (interm aprch fix)
  MONITOR INDICATED/COMMANDED HEADING
  EVALUATE HEADING CHANGE REQUIREMENTS
  MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONFIGURE NAVIGATION RADIOS
  TUNE JFK ILS

DECELERATE AIRCRAFT (to 180 KTS)
  SELECT SPEED DECREASE TARGET
  COMMAND THRUST DECREASE LEVEL
  MONITOR INDICATED/COMMANDED SPEED
  EVALUATE SPEED DECREASE PROGRESS
  MODIFY THRUST COMMANDS AS REQUIRED

180 KNOTS ATTAINED

MAINTAIN AIRCRAFT SPEED (at 180 KTS)
  MONITOR INDICATED/COMMANDED SPEED
  EVALUATE SPEED CHANGE REQUIREMENTS
  MODIFY THRUST COMMANDS AS REQUIRED

CONFIGURE LIFT AUGMENTATION SYSTEM FOR LANDING
  EXTEND SLATS (leading edge)
  EXTEND FLAPS (trailing edge) TO 28 DEGREES

DECELERATE AIRCRAFT (to 155 KTS)
  SELECT SPEED DECREASE TARGET
  COMMAND THRUST DECREASE LEVEL
  MONITOR INDICATED/COMMANDED SPEED
  EVALUATE SPEED DECREASE PROGRESS
  MODIFY THRUST COMMANDS AS REQUIRED

155 KNOTS ATTAINED

MAINTAIN AIRCRAFT SPEED (at 155 KTS)
  MONITOR INDICATED/COMMANDED SPEED
  EVALUATE SPEED CHANGE REQUIREMENTS
  MODIFY THRUST COMMANDS AS REQUIRED

COMMUNICATE WITH NEW YORK APPROACH CONTROL
  RECEIVE APPROACH INSTRUCTIONS
  ACKNOWLEDGE APPROACH INSTRUCTIONS

END APPROACH INSTRUCTIONS ACKNOWLEDGE

DESCEND TO 1900 FT MSL
  SELECT ALTITUDE DESCENT TARGET
  COMMAND PITCH DOWN ATTITUDE
  MONITOR INDICATED/COMMANDED ALTITUDE
  EVALUATE ALTITUDE DECREASE PROGRESS
  MODIFY PITCH COMMANDS AS REQUIRED

1.4.2.2 SEGMENT: DESCENT TO OUTER MARKER

CROSS INTERMEDIATE APPROACH FIX

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
  MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
  MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT SPEED (at 155 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT DESCENT (to 1900 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

ON COURSE

TURN LEFT TO NEW HEADING (005 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

MAINTAIN AIRCRAFT HEADING (FAF)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

ARRIVE AT 1900 FT MSL

MAINTAIN AIRCRAFT ALTITUDE (at 1900 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

CROSS FINAL APPROACH FIX

TURN LEFT TO NEW HEADING (313 degrees)
SELECT ROLL RATES
MONITOR FOR ROLL IN CUE
COMMAND ROLL IN
MONITOR INDICATED/COMMANDED ROLL RATE
EVALUATE TURN PROGRESS
MODIFY ROLL RATE AS REQUIRED
MONITOR FOR ROLL OUT CUE
COMMAND ROLL OUT
EVALUATE RECOVERY PROGRESS
MODIFY ROLL RATE AS REQUIRED

ON COURSE/LOCALIZER

MAINTAIN AIRCRAFT HEADING (aprch runway)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONFIGURE LANDING GEAR SYSTEM
LOWER LANDING GEAR

CONFIGURE TRAILING EDGE LIFT AUGMENTATION SYSTEM
EXTEND FLAPS TO 35 DEGREES

VERIFY GROUND MANUEVERING BRAKE SYSTEM OPERATIONAL
VERIFY BRAKE PRESSURE NORMAL

CONFIGURE DRAG AUGMENTATION SYSTEM
ARM SPOILERS

CONFIGURE TRAILING EDGE LIFT AUGMENTATION SYSTEM
EXTEND FLAPS TO 50 DEGREES

INTERCEPT GLIDE SLOPE

VERIFY AIRCRAFT CONFIGURED FOR LANDING
ACCESS BEFORE LANDING CHECKLIST
VERIFY LANDING GEAR DOWN AND LOCKED
VERIFY EMERGENCY BRAKING SYSTEM ARMED
VERIFY SPOILERS ARMED FOR LANDING
VERIFY FLAPS/SLATS EXTENDED FOR LANDING
VERIFY ALTIMETERS SET FOR LOCAL PRESSURE
STOW BEFORE LANDING CHECKLIST

PREPARE FOR MISSED APPROACH
SELECT MISSED APPROACH RECOVERY ALTITUDE

1.4.3 PHASE: LAND

1.4.3.1 SEGMENT: DESCENT TO DECISION HEIGHT

CROSS OUTER MARKER

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT SPEED (at 155 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT HEADING (approach runway)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT ALTITUDE (at 1900 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

CONFIGURE VHF COMMUNICATION SYSTEM
TUNE JFK TOWER

COMMUNICATE WITH JFK TOWER
REPORT AIRCRAFT POSITION
RECEIVE LANDING CLEARANCE
ACKNOWLEDGE LANDING CLEARANCE

END LANDING CLEARANCE ACKNOWLEDGE

DESCEND TO 100 FT MSL
SELECT ALTITUDE DESCENT TARGET
COMMAND PITCH DOWN ATTITUDE
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

CROSS MIDDLE MARKER

1.4.3.2 SEGMENT: DESCENT TO TOUCHDOWN

ARRIVE AT DECISION HEIGHT

MAINTAIN AWARENESS OF OTHER FLIGHT CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AWARENESS OF FLIGHT PLAN
MONITOR FLIGHT PROGRESS

MAINTAIN AIRCRAFT HEADING (aprch runway)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

MAINTAIN AIRCRAFT SPEED (at 155 KTS)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

CONTINUE AIRCRAFT DESCENT (to 100 FT MSL)
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

ARRIVE AT 100 FT AGL

DECELERATE AIRCRAFT (to touchdown speed)
SELECT SPEED DECREASE TARGET
COMMAND IDLE FORWARD THRUST
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

ROTATE AIRCRAFT TO LANDING ATTITUDE (flare)
SELECT NOSE UP ATTITUDE
COMMAND PITCH UP MAGNITUDE
MONITOR INDICATED/COMMANDED ATTITUDE
EVALUATE ATTITUDE CHANGE REQUIREMENTS
MODIFY PITCH COMMANDS AS REQUIRED

DESCEND TO TOUCHDOWN
MONITOR INDICATED/COMMANDED ALTITUDE
EVALUATE ALTITUDE DECREASE PROGRESS
MODIFY PITCH COMMANDS AS REQUIRED

1.4.3.3 SEGMENT: LANDING GROUND ROLL

MAIN GEAR TOUCHDOWN

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN AIRCRAFT HEADING (runway centerline)
MONITOR INDICATED/COMMANDED HEADING
EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY ROLL/YAW COMMANDS AS REQUIRED

CONTINUE DECELERATION (to touchdown speed)
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

NOSE GEAR TOUCH DOWN

MAINTAIN AIRCRAFT HEADING (runway centerline)
MONITOR INDICATED/COMMANDED HEADING

EVALUATE HEADING CHANGE REQUIREMENTS
MODIFY STEERING COMMANDS AS REQUIRED

CONFIGURE GROUND BRAKING SYSTEM
ENGAGE GROUND MANEUVERING BRAKE SYSTEM

ACTIVATE DRAG AUGMENTATION SYSTEM
DEPLOY SPOILERS

DECELERATE AIRCRAFT (to 80 KTS)
SELECT SPEED DECREASE TARGET
COMMAND FULL REVERSE THRUST
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

80 KTS ATTAINED

DECELERATE AIRCRAFT (to 60 KTS)
SELECT SPEED DECREASE TARGET
COMMAND IDLE REVERSE THRUST
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

60 KTS ATTAINED

DECELERATE AIRCRAFT (to a stop)
SELECT SPEED DECREASE TARGET
COMMAND IDLE FORWARD THRUST
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED DECREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

AIRCRAFT STOPPED

TERMINATE ELAPSED FLIGHT TIME MEASUREMENT

CONFIGURE AUTOPILOT SYSTEM
DEACTIVATE AUTOPILOT

CONFIGURE GROUND BRAKING SYSTEM
DISENGAGE GROUND MANEUVERING BRAKE

ACCELERATE TO TAXI SPEED
SELECT SPEED INCREASE TARGET
COMMAND REVERSE THRUST INCREASE
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED INCREASE PROGRESS
MODIFY THRUST COMMANDS AS REQUIRED

TAXI SPEED ATTAINED

MAINTAIN TAXI SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

1.4.4 PHASE: TAXI IN

1.4.4.1 SEGMENT: TAXI TO RAMP

ARRIVE AT RUNWAY THRESHOLD

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTY LINE
MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
MONITOR GROUND/FLIGHT PATH

MAINTAIN TAXI SPEED
MONITOR INDICATED/COMMANDED SPEED
EVALUATE SPEED CHANGE REQUIREMENTS
MODIFY THRUST COMMANDS AS REQUIRED

TURN 90 DEGREES RIGHT
- SELECT STEERING OPTION
- COMMAND RIGHT TURN
- MONITOR INDICATED/COMMANDED POSITION
- EVALUATE TURN PROGRESS
- MODIFY STEERING COMMANDS AS REQUIRED

ON COURSE

MAINTAIN AIRCRAFT HEADING (arrival gate)
- MONITOR INDICATED/COMMANDED HEADING
- EVALUATE HEADING CHANGE REQUIREMENTS
- MODIFY STEERING COMMANDS AS REQUIRED

COMMUNICATE WITH JFK GROUND CONTROL
- REQUEST PARKING INSTRUCTIONS
- RECEIVE PARKING INSTRUCTIONS
- ACKNOWLEDGE PARKING INSTRUCTIONS

END PARKING INSTRUCTIONS ACKNOWLEDGE

VERIFY AIRCRAFT CONFIGURED FOR GATE ENGAGEMENT
- ACCESS AFTER LANDING CHECKLIST
- RETRACT FLAPS (trailing edge lift)
- RETRACT SLATS (leading edge lift)
- DISARM SPOILERS
- DEACTIVATE NAVIGATION LIGHTS
- DEACTIVATE ANTI-COLLISION LIGHTS
- DEACTIVATE HIGH INTENSITY RECOGNITION LIGHTS
- DEACTIVATE MAIN LANDING LIGHTS
- ACTIVATE GROUND FLOOD LIGHTS
- DEACTIVATE ANTI-ICE SYSTEMS AS REQUIRED
- DEACTIVATE IGNITION SYSTEM
- DEACTIVATE WEATHER RADAR SYSTEM AS REQUIRED
- STOW AFTER LANDING CHECKLIST

1.4.4.2 SEGMENT: GATE ENGAGEMENT

ARRIVE AT RAMP THRESHOLD

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
- MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
- MONITOR AIRCRAFT SYSTEMS STATUS

MAINTAIN AWARENESS OF OTHER AIRCRAFT/OBSTRUCTIONS
- MONITOR GROUND/FLIGHT PATH

DECELERATE TO GATE ENGAGEMENT SPEED
- SELECT SPEED DECREASE TARGET
- COMMAND FORWARD THRUST DECREASE
- MONITOR INDICATED/COMMANDED SPEED
- EVALUATE SPEED DECREASE PROGRESS
- MODIFY THRUST COMMANDS AS REQUIRED

GATE ENGAGEMENT SPEED ATTAINED

STEER AIRCRAFT TOWARD GATE
- SELECT STEERING OPTIONS (nosewheel/rudder pedals)
- COMMAND STEERING DIRECTION/MAGNITUDE
- MONITOR INDICATED/COMMANDED POSITION
- EVALUATE MOVEMENT PROGRESS
- MODIFY STEERING COMMANDS AS REQUIRED

DECELERATION CUE

DECELERATE TO A STOP
- SELECT SPEED DECREASE TARGET
- COMMAND FORWARD THRUST DECREASE
- MONITOR INDICATED/COMMANDED SPEED
- EVALUATE SPEED DECREASE PROGRESS
- MODIFY THRUST COMMANDS AS REQUIRED

CONFIGURE GROUND BRAKE SYSTEM

ENGAGE GROUND MANEUVERING BRAKE (toe brakes)

1.4.5 PHASE: POST FLIGHT

1.4.5.1 SEGMENT: SYSTEM SHUTDOWN

GATE ENGAGEMENT COMPLETED

MAINTAIN AWARENESS OF OTHER GROUND CONTROL ACTIVITY
MONITOR PARTY LINE

MAINTAIN AWARENESS OF AIRCRAFT SYSTEMS WARNINGS/CAUTIONS/ADVISORIES
MONITOR AIRCRAFT SYSTEMS STATUS

CONFIGURE GROUND BRAKE SYSTEM
ENGAGE PARKING BRAKE SYSTEM

CONFIGURE PERSONNEL WARNING SYSTEM
DEACTIVATE SEAT BELT/NO SMOKING ANNUNCIATION

COMMUNICATE WITH JFK GROUND CONTROL
REPORT GATE ENGAGEMENT COMPLETED
REQUEST ENGINE SHUTDOWN CLEARANCE
RECEIVE ENGINE SHUTDOWN CLEARANCE
ACKNOWLEDGE ENGINE SHUTDOWN CLEARANCE

COMMUNICATE WITH CABIN
ANNOUNCE ARRIVAL
ANNOUNCE CONNNECTION DATA AS REQUIRED

CONFIGURE FUEL SYSTEM FOR LAYOVER

DEACTIVATE PROPULSION SYSTEM FOR LAYOVER

CONFIGURE MAIN ELECTRICAL SYSTEM FOR LAYOVER

CONFIGURE HYDRAULIC SYSTEM FOR LAYOVER

CONFIGURE PNEUMATIC SYSTEM FOR LAYOVER

VERIFY AIRCRAFT CONFIGURED FOR LAYOVER
ACCESS BEFORE LEAVING AIRCRAFT CHECKLIST
DEACTIVATE NAVIGATION REFERENCE SYSTEM (IRUs)
VERIFY WEATHER RADAR SYSTEM DEACTIVATED
DEACTIVATE ELECTRONIC DISPLAY SYSTEM
DISARM ANTI-SKID BRAKING SYSTEM
DEACTIVATE WINDSCREEN ANTI-WEATHER SYS (anti-ice,defog,wipers)
DEACTIVATE EXTERNAL LIGHTING SYSTEM
DEACTIVATE EMERGENCY LIGHTING SYSTEM
DEACTIVATE EMERGENCY POWER SYSTEM
DEACTIVATE COMMUNICATIONS SYSTEM
DEACTIVATE INTERNAL LIGHTING SYSTEM
DEACTIVATE BATTERY POWER SYSTEM
STOW BEFORE LEAVING AIRCRAFT CHECKLIST

CROSS AIRCRAFT EXIT DOOR THRESHOLD

APPENDIX F

CONTINGENCY FILE

The Contingency File database lists the functions which are to be implemented for each class of failure. The contingencies are those introduced on page 14 of the Flight Scenario Description. Contingencies addressed are:

- Hydraulic Failure
- Smoke and Fumes of Unknown Origin
- Engine Fire
- Fuel Dump
- Main Gear Extension Failure
- Loss of All Generators
- Wind Shear/Microburst

For each class of contingency, the functions are listed in the order in which they are to be executed

CONTINGENCY FUNCTION

HYDRAULIC FAILURE

MONITOR FOR HYDRAULIC POWER SYSTEM FAILURES
- MONITOR PRESSURES, TEMPERATURES, FLUID LEVELS, ETC.
- DETECT SUDDEN, SEVERE LOSS OF HYDRAULIC FLUID IN SYSTEM #3

INITIATE CONTINGENCY PROCEDURES
- ALERT PERSONNEL OF FAILURE

EVALUATE EXTENT OF FAILURE
- OBSERVE HYDRAULIC SYSTEM #3 FAILURE INDICATIONS
- OBSERVE ABSENCE OF OTHER ALERTS
- CONCLUDE SINGLE HYDRAULIC SYSTEM FAILURE

RESET CAUTION ALERTING SYSTEM
- DEACTIVATE ALERT LOGIC
- OBSERVE ABSENCE OF OTHER ALERTS

INITIATE HYDRAULIC SYSTEM FAILURE PROCEDURES
- ACCESS CHECKLIST

DEACTIVATE #3 HYDRAULIC SYSTEM
- STOP ENGINE DRIVEN PUMPS
- STOP 1-3 HYDRAULIC POWER TRANSFER PUMP

EVALUATE OPERATIONAL CONSEQUENCES OF FAILURE
- CONSIDER EFFECTS ON FLAP/SLAT EXTENSIONS/RETRACTIONS
- CONSIDER EFFECTS ON SPOILER EXTENTIONS
- CONSIDER EFFECTS ON LANDING GEAR EXTENTIONS
- CONSIDER EFFECTS ON BRAKING FORCE
- CONSIDER EFFECTS ON NOSEWHEEL STEERING

MODIFY FLIGHT OPERATIONS AS REQUIRED TO COMPENSATE
TERMINATE HYDRAULIC SYSTEM FAILURE PROCEDURE
STOW CHECKLIST

SMOKE & FUMES OF UNKNOWN ORIGIN

MONITOR FOR FIRE CONTINGENCIES
    MONITOR FOR FUMES
    MONITOR FOR SMOKE
    MONITOR FOR HEAT
    DETECT SMOKE AND FUMES EMANATING FROM THROTTLE QUADRANT
INITIATE CONTINGENCY PROCEDURES
    ALERT PERSONNEL ABOUT FIRE
PREVENT SMOKE INHALATION
    DIRECT PERSONNEL TO DON OXYGEN MASKS
    DON OXYGEN MASKS
    OPEN 02 SUPPLY VALVES
COMMUNICATE WITH CABIN
    REPORT COMM STATUS
    ACKNOWLEDGE REPORT
PREVENT VISUAL IMPAIRMENT
    DIRECT COCKPIT PERSONNEL TO DON SMOKE GOGGLES
    DON SMOKE GOGGLES
CLASSIFY SMOKE SOURCE TYPE
    SCAN AIR CONDITIONING OUTLETS FOR SMOKE EMISSIONS
    CONCLUDE SMOKE IS ELECTRICAL IN ORIGIN
INITIATE ELECTRICAL SMOKE & FUMES PROCEDURES
    ACCESS CHECKLIST
ELIMINATE ONE POTENTIAL SMOKE SOURCE
    DEACTIVATE CABIN ELECTRICAL POWER DISTRIBUTION SYSTEM
EVALUATE SMOKE STATUS
    SCAN COCKPIT AREA FOR SMOKE
    CONCLUDE SMOKE IS NOT DECREASING
ACTIVATE CLEARED SYSTEM
    ACTIVATE CABIN ELECTRICAL POWER DISTRIBUTION SYSTEM
ELIMINATE ANOTHER POTENTIAL SMOKE SOURCE
    DEACTIVATE #3 ELECTRICAL POWER DISTRIBUTION SYSTEM
    DEACTIVATE #1 AIR CONDITIONING PACK & AIR SUPPLY
EVALUATE SMOKE STATUS
    SCAN COCKPIT AREA FOR SMOKE & FUMES
    CONCLUDE SMOKE IS NOT DECREASING
ACTIVATE CLEARED SYSTEM
    ACTIVATE #3 ELECTRICAL POWER DISTRIBUTION SYSTEM
    ACTIVATE #1 AIR CONDITIONING PACK & AIR SUPPLY
ELIMINATE ANOTHER POTENTIAL SMOKE SOURCE
    DEACTIVATE #2 ELECTRICAL POWER DISTRIBUTION SYSTEM
    DEACTIVATE #3 AIR CONDITIONING PACK & AIR SUPPLY
EVALUATE SMOKE STATUS
    SCAN COCKPIT AREA FOR SMOKE & FUMES

CONCLUDE SMOKE IS DECREASING
EVALUATE O2 MASK/SMOKE GOGGLE REQUIREMENT
SCAN COCKPIT AREA FOR SMOKE & FUMES
CONCLUDE SMOKE HAS DISPERSED
DIRECT CREW TO REMOVE MASKS & GOGGLES
DOFF MASKS & GOGGLES
CLOSE O2 SUPPLY VALVES
TERMINATE CONTINGENCY PROCEDURES
STOW SMOKE & FUMES CHECKLIST

ENGINE FIRE

MONITOR FOR PROPULSION SYSTEM FAILURES
MONITOR FOR FIRES, OIL, FUEL PROBLEMS, ETC.
DETECT FIRE IN #3 ENGINE
INITIATE CONTINGENCY PROCEDURES
ALERT PERSONNEL OF #3 ENGINE FIRE
EVALUATE EXTENT OF FAILURE
OBSERVE ENGINE #3 FAILURE INDICATION
OBSERVE ABSENSE OF OTHER ENGINE ALERTS
CONCLUDE SINGLE ENGINE FAILURE
INITIATE ENGINE FIRE SHUTDOWN PROCEDURE
ACCESS CHECKLIST
DECREASE #3 ENGINE THRUST TO MINIMUM
COMMAND IDLE THRUST
OBSERVE IDLE THRUST INDICATION
DEACTIVATE #3 ENGINE FUEL SYSTEM
CLOSE MAIN FUEL VALVE
CLOSE FUEL CROSS-FEED VALVES
STOP FUEL FEED PUMPS
EXTINGUISH #3 ENGINE FIRE
DISCHARGE FIRE AGENT
OBSERVE FIRE INDICATION ELIMINATED
CONCLUDE FIRE EXTINGUISHED
DEACTIVATE #3 HYDRAULIC SYSTEM
CLOSE HYDRAULIC FLUID SUPPLY VALVES
STOP ENGINE-DRIVEN HYDRAULIC PUMPS
ELMINATE #3 ENGINE BLEED AIR SYSTEM
CLOSE BLEED AIR VALVE
CLOSE PNEUMATIC ISOLATION VALVE
COMMUNICATE WITH CABIN
ANNOUNCE FIRE STATUS AND FLIGHT PLANS
BRIEF PERSONNEL ON DUTIES AND RESPONSIBILITIES
INITIATE FUEL DUMP PROCEDURE
>SEE: FUEL DUMP CONTINGENCY
COMMUNICATE WITH CONTROL CENTER
REPORT FIRE OUT, FUEL DUMP IN PROGRESS
RECEIVE AKNOWLEDGEMENT
TERMINATE FUEL DUMP
>SEE FUEL DUMP CONTINGENCY

COMMUNICATE WITH CONTROL CENTER
    REQUEST LANDING CLEARANCE TO NEAREST AIRPORT
    RECEIVE CLEARANCE

FUEL DUMP PROCEDURE

EVALUATE FUEL DUMPING CONSTRAINTS
    CONSIDER AIRCRAFT ALTITUDE/AIRSPEED
    CONCLUDE FUEL DUMP CONSTRAINTS MET
DECREASE EXPLOSION/FIRE DANGER
    DEACTIVATE GALLEY ELECTRICAL POWER
    DEACTIVATE AIR RECIRCULATION FANS
    DEACTIVATE CABIN READING AND SIDEWALL LIGHTS
EVALUATE FUEL DUMP MAGNITUDE
    CONSIDER REMAINING FLIGHT TIME/DISTANCE
    COMPUTE FUEL REQUIREMENT AS NECESSARY
    SELECT FUEL DUMP MAGNITUDE
PLAN FUEL TANK TRANSFER
    SELECT FUEL TANK TRANSFER SEQUENCE
    SELECT FUEL TANK LEVELS
INITIATE FUEL DUMPING PROCEDURE
    COMMAND FUEL DUMPING PROCEDURE START
VERIFY FUEL FEED TO ENGINES REMAINS UNINTERRUPTED
    START APPROPRIATE ENGINE FEED PUMPS
PREVENT INADVERTENT FEED INTO FUEL TANKS
    CLOSE APPROPRIATE FILL VALVES
INITIATE FUEL TANK TRANSFER
    START APPROPRIATE TRANSFER PUMP
    OPEN APPROPRIATE CROSSFEED VALVE
    REPEAT FOR EACH REQUIRED TRANSFER
INITIATE FUEL DUMPING
    OPEN FUEL DUMP VALVES
EVALUATE FUEL TANK LEVEL STATUS
    OBSERVE EACH INDICATED/COMMANDED FUEL TANK LEVEL
    CONSIDER CONTINUATION OR TERMINATION OF EACH TRANSFER
    CONCLUDE THAT EACH TRANSFER SHOULD/SHOULD NOT CONTINUE
    REPEAT FOR EACH REMAINING FUEL TANK
    REPEAT INTERMITTANTLY
TERMINATE FUEL TANK TRANSFER
    STOP ASSOCIATED TRANSFER PUMP
    CLOSE ASSOCIATED CROSSFEED VALVE AS REQUIRED
    REPEAT FOR EACH FUEL TANK TO BE TERMINATED
EVALUATE FUEL TRANSFER PROGRESS
    CONSIDER PLANNED TANK TRANSFER SEQUENCE
    CONSIDER CURRENT TANK TRANSFER ACTIVITY
    CONCLUDE THAT NEXT TRANSFER SHOULD/SHOULD NOT BE INITIATED
    REPEAT INTERMITTANTLY
INITIATE NEW FUEL TANK TRANSFER
    START APPROPRIATE TRANSFER PUMP

OPEN APPROPRIATE CROSSFEED VALVE
REPEAT FOR EACH REQUIRED TRANSFER
EVALUATE FUEL DUMPING PROGRESS
OBSERVE INDICATED/COMMANDED AIRCRAFT FUEL LEVEL/WEIGHT
CONSIDER CONTINUATION OR TERMINATION OF FUEL DUMP
CONCLUDE THAT FUEL DUMP SHOULD/SHOULD NOT CONTINUE
REPEAT IF FUEL DUMP CONTINUES
TERMINATE FUEL DUMPING PROCEDURE
CLOSE FUEL DUMP VALVES

MAIN GEAR EXTENSION FAILURE

LOWER LANDING GEAR
COMMAND LANDING GEAR DOWN
MONITOR INDICATED/COMMANDED POSITIONS
DETECT DISCREPANCY BETWEEN CMD/IND POSITION
INITIATE CONTINGENCY PROCEDURES
ALERT PERSONNEL OF FAILURE
ASSESS EXTENT OF FAILURE
OBSERVE NOSE GEAR DOWN/LOCKED
OBSERVE LEFT MAIN GEAR NOT DOWN/LOCKED
OBSERVE CENTER GEAR DOWN/LOCKED
OBSERVE RIGHT MAIN GEAR DOWN/LOCKED
CONCLUDE FAILURE LIMITED TO LEFT MAIN GEAR
INITIATE MAIN GEAR EXTENTION FAILURE PROCEDURE
ACCESS CHECKLIST
EVALUATE HYDRAULIC SYSTEM STATUS
OBSERVE HYDRAULIC SYSTEM (#3) QUANTITY NORMAL
OBSERVE HYDRAULIC SYSTEM (#3) PRESSURE NORMAL
CONCLUDE FAILURE NOT HYDRAULIC SYSTEM RELATED
EVALUATE OPERATIONAL LIMITATIONS OF ALTERNATE GEAR EXTENSION
OBSERVE AIRSPEED BELOW 230 KNOTS
CONCLUDE SPEED BELOW MAX SPEED FREE FALL LIMIT
PERFORM ALTERNATIVE GEAR EXTENTION PROCEDURE
COMMAND LANDING GEAR DOWN
OBSERVE GEAR INDICATED/COMMANDED POSITION
CONCLUDE GEAR DOWN AND LOCKED
TERMINATE MAIN GEAR EXTENTION FAILURE PROCEDURE
STOW CHECKLIST

LOSS OF ALL GENERATORS

MONITOR FOR ELECTRICAL POWER SYSTEM FAILURES
MONITOR GENERATION, DISTRIBUTION, ETC,
DETECT FAILURE OF ELECTRICAL POWER GENERATION
INITIATE CONTINGENCY PROCEDURES
ALERT PERSONNEL OF FAILURE

EVALUATE EXTENT OF FAILURE
    OBSERVE GENERATOR FAILURE INDICATIONS
    OBSERVE ABSENSE OF OTHER ALERTS
    CONCLUDE ALL GENERATORS LOST BUT ENGINES UNAFFECTED
RESET CAUTION ALERTING SYSTEM
    DEACTIVATE ALERT LOGIC
    OBSERVE ABSENSE OF ALERTS
INITIATE LOSS OF ELECTRICAL POWER GENERATION PROCEDURES
    ACCESS CHECKLIST
ELIMINATE AC ELECTRICAL POWER BUSES
    OPEN AC BUS TIE RELAYS
ARM GENERATOR CONTROL LOGIC
    CLOSE GENERATOR CONTROL RELAYS
EVALUATE EMERGENCY POWER BUS STATUS
    OBSERVE EMERGENCY POWER BUS POWERED
    CONCLUDE SHORT TERM EMERGENCY POWER SOURCE ACTIVATED
EVALUATE LONG TERM EMERGENCY POWER SOURCE REQUIREMENTS
    CONSIDER FLIGHT PHASE CRITICALITY
    CONSIDER REMAINING FLIGHT TIME
    CONCLUDE LONG TERM EMERGENCY POWER SOURCE REQUIRED
ACTIVATE LONG TERM EMERGENCY POWER SOURCE
    ENGAGE AIR DRIVEN GENERATOR (ADG)
    CLOSE ADG ELECTRICAL POWER DISTRIBUTION RELAY
DEACTIVATE SHORT TERM EMERGENCY POWER SOURCE
    OPEN BATTERY ELECTRICAL POWER DISTRIBUTION RELAY
EVALUATE SUPPLEMENTAL ELECTRICAL POWER REQUIREMENTS
    CONSIDER FLIGHT PHASE CRITICALITY
    CONSIDER REMAINING FLIGHT TIME
    CONCLUDE AUXILIARY ELECTRICAL POWER REQUIRED
EVALUATE AUXILIARY ELECTRICAL POWER CONSTRAINTS
    CONSIDER ALTITUDE RESTRICTIONS
    CONSIDER AIRCRAFT ALTITUDE
    CONCLUDE DESCENT REQUIRED
COMMUNICATE WITH AIR TRAFFIC CONTROL
    REQUEST DESCENT CLEARANCE

WIND SHEAR/ MICROBURST

MONITOR FOR WEATHER RELATED DISTURBANCES
    OBSERVE AIRSPEED, ETC
    DETECT WIND SHEAR MICROBURST IN PROGRESS
ACCELERATE TO CLIMB VELOCITY
    SELECT GO AROUND THRUST LIMIT
    COMMAND MAXIMUM FORWARD THRUST
    OBSERVE INDICATED/COMMANDED VELOCITY
    CONSIDER SPEED INCREASE PROGRESS
    MODIFY THRUST COMMAND AS REQUIRED
ASCEND TO SAFE ALTITUDE
    SELECT NOSE-UP ALTITUDE TARGET

COMMAND PITCH-UP ATTITUDE
OBSERVE INDICATED/COMMANDED ALTITUDE
CONSIDER ALTITUDE INCREASE PROGRESS
MODIFY PITCH COMMAND AS REQUIRED
COMMUNICATE WITH CONTROL TOWER
REPORT GO-AROUND MANEUVER
RECEIVE ACKNOWLEDGEMENT/INFO REQUEST
REPORT INTENTION TO PROCEED TO WAYPOINT AND HOLD
RECEIVE NEW APPROACH INSTRUCTIONS
ACKNOWLEDGE APPROACH INSTRUCTIONS
CONFIGURE TRAILING EDGE LIFT AUGMENTATION SYSTEM
RETRACT FLAPS TO 28 DEGREES
VERIFY POSITIVE RATE OF CLIMB ATTAINED
OBSERVE UPWARD VELOCITY VECTOR
CONFIGURE LANDING GEAR SYSTEM
RAISE LANDING GEAR

APPENDIX G

ANALYSIS FORMAT

This database relates functions to other data which contribute to the function allocation decision. Each page addresses one segment of the mission. On page G-2, for example, Segment 1.2.1.1, Gate Disengagement, lists the functions which must be accomplished in order to accomplish the segment. These functions are listed in the center column headed "Function." The functions have been aggregated into the primary function categories described on page 20 of the Final Report. These are:

F1. Manage Flight Coordination
F2. Manage Aircraft Systems/Procedures
F3. Manage Aircraft Movement
F4. Manage Flight Plan
F5. Manage Contingencies

For segment 1.2.1.1, categories F3 and F4 are not used.

The Analysis Format shows the time window for each function and the relationship of the function to the events which apply to it. It also relates a given function to the events which must precede or follow it and identifies whether the function is accomplished intermittently, continuously or at discrete points in time. It also characterizes the function as an action, as communication, as information, or as a decision.

ANALYSIS FORMAT

▽ Event
< > Time Window
■ Time Duration

	Event	Time
E 1	Complete after start checklist	00:00:00
2	End backing clearance acknow	
3	Attain backing speed	
4	Deceleration cue	
5	Aircraft stopped	00:00:45
6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.1	Phase:	Taxi out
1.2.1.1	Segment:	Gate disengagement

Event/Function

	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Request backing clearance	E 1				Discrete	Comm
c	Receive backing clearance			F1b		Discrete	Comm
d	Acknowledge backing clearance			F1c		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Disengage parking brake system	E2				Discrete	Action
c	Disengage ground maneuvering brake sys	E2				Discrete	Action
d	Engage ground maneuvering brake sys	E4			F3d	Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path			F2c		Intermit	Inform
b	Steer away from gate			F2c	F3c-e	Continu	
	1 Select steering option(nsewhl/ruddr)					Discrete	Decision
	2 Command steering directn/magnitude					Discrete	Action
	3 Monitor indicated/commanded position					Intermit	Inform
	4 Evaluate movement progress					Intermit	Decision
	5 Modify steering commands as required					Intermit	Action
c	Accelerate to backing speed			F2c	F3b	Continu	
	1 Select speed increase target					Discrete	Decision
	2 Command reverse thrust increase					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed increase progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
d	Maintain backing speed	E3		F3c	F3b	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
e	Decelerate to a stop	E4		F3d	F2d,3b	Continu	
	1 Select speed decrease target					Discrete	Decision
	2 Command reverse thrust decrease					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
F4	Manage Flight Plan						
F5	Manage Contingencies						

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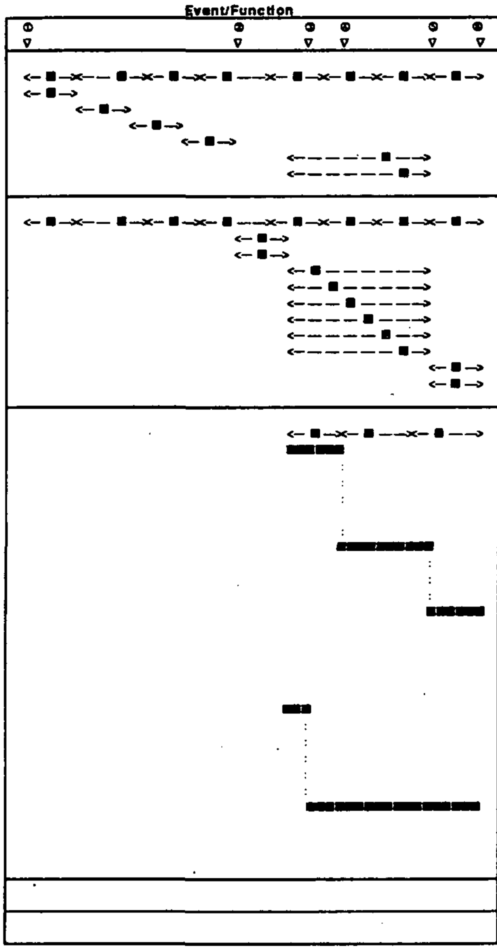
ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Aircraft stopped	00:00:45
	2	End taxi clearance acknow	
	3	On course	
	4	Attain taxi speed	
	5	Deceleration cue	
	6	Aircraft stopped	00:02:45

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.1	Phase:	Taxi out
1.2.1.2	Segment:	Departure taxi

Event/Function



	Function	Dependency Event Pro	Dependency Event Ret	Dependency Function Seq	Dependency Function Con	Performance Schedule	Performance Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Report aircraft clear of gate	E 1				Discrete	Comm
c	Request taxi clearance			F1b		Discrete	Comm
d	Receive taxi clearance			F1c		Discrete	Comm
e	Acknowledge taxi clearance			F1d		Discrete	Comm
f	Brief Passengers/Crew			F2c		Discrete	Comm
g	Receive Cabin Report			F2c		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Disengage ground maneuvering brake sy	E2				Discrete	Action
c	Access taxi checklist	E2				Discrete	Action
d	Extend flaps to 25 degrees			F2c		Discrete	Action
e	Extend slats			F2c		Discrete	Action
f	Arm spoilers			F2c		Discrete	Action
g	Arm emergemcy braking system			F2c		Discrete	Action
h	Verify flight controls operability			F2c		Discrete	Decision
i	Configure electronic display system			F2c		Discrete	Action
j	Stow taxi checklist		E6			Discrete	Action
k	Engage ground maneuvering brake sys	E5	E6		F3d	Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path			F2b		Intermit	Inform
b	Accelerate to taxi speed			F2b	F3ef	Continu	
	1 Select speed increase target					Discrete	Decision
	2 Command forward thrust increase					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed increase progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
c	*Maintain taxi speed*	E 4		F3b	*F3f*	*Continu*	
	1 Monitor Indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Decelerate to a stop	E 5		F3c	F2k,3f	Continu	
	1 Select speed decrease target					Discrete	Decision
	2 Command forward thrust decrease					Discrete	Action
	3 Monitor Indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
e	Alter heading 90 degrees left			F2b	F3b	Continu	
	1 Select steering option					Discrete	Decision
	2 Command left turn					Discrete	Action
	3 Monitor indicated/commanded position					Intermit	Inform
	4 Evaluate turn progress					Intermit	Decision
	5 Modify steering commands as required					Intermit	Action
f	Maintain Heading	E 3		F3e	F3b-d	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify steering commands as required					Intermit	Action
F4	Manage Flight Plan						
F5	Manage Contingencies						

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ANALYSIS FORMAT →

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Aircraft stopped	00:02:45
	2	End clearance ack	00:03:45
	3		
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.1	Phase:	Taxi out
1.2.1.3	Segment:	Departr rnwy preposn hold

Event/Function		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
⊕ ∇ … ⊕ ∇	F1	Manage Flight Coordination						
<-■-x-■-x-■-x-■-x-■-x-■-x-■-x-■-x-■->	a	Monitor Partyline					Intermit	Inform
<--■-->	b	Report arrival at runway threshhold	E1				Discrete	Comm
<--■-->	c	Request p & h clearance			F1b		Discrete	Comm
<--■-->	d	Receive p & h clearance			F1c		Discrete	Comm
<--■-->	e	Acknowledge p & h clearance			F1d		Discrete	Comm
<----------------■-->	f	Direct crew to T/O positions			F2b		Discrete	Comm
<-------------■---->	g	Receive cabin report			F2b		Discrete	Comm
	F2	Manage Aircraft Systems/Procedures						
<-■-x-■-x-■-x-■-x-■-x-■-x-■-x-■-x-■->	a	Monitor systems status					Intermit	Inform
<-■->	b	Access before takeoff checklist	E1				Discrete	Action
<-■---------------->	c	Verify anti-ice system set as reqd			F2b		Discrete	Decision
<----■------------->	d	Activate main landing lights			F2b		Discrete	Action
<--------■--------->	e	Activate nose landing/taxi lights			F2b		Discrete	Action
<-----------■------>	f	Activate high intensity recog. lights			F2b		Discrete	Action
<-■->	g	Stow before takeoff checklist					Discrete	Action
<-■->	h	Tune LA tower			F2g		Discrete	Action
	F3	Manage Aircraft Movement						
	F4	Manage Flight Plan						
	F5	Manage Contingencies						

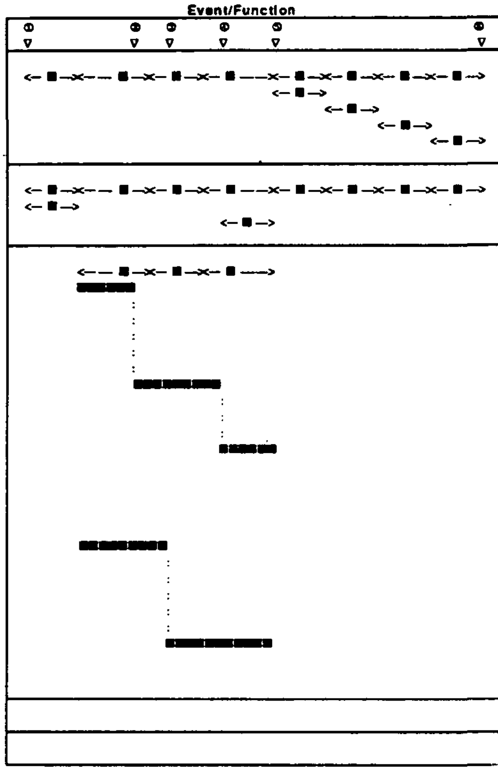
ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	End clearance acknow	00:03:45
2	Taxi speed	
3	On course	
4	Deceleration cue	
5	Aircraft stopped	
6	End clearance acknow	00:05:15

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.1	Phase:	Taxi out
1.2.1.4	Segment:	Deprtr rnwy posn holding

Event/Function



		Dependency				Performance	
		Event		Function			
	Function	Pro	Ret	Seq	Con	Schedule	Category
F1	Manage Flight Coordination						
a	Monitor partyline					Intermit	Inform
b	Report arrival at T/O position	E5				Discrete	Comm
c	Request T/O clearance			F1b		Discrete	Comm
d	Receive T/O clearance			F1c		Discrete	Comm
e	Acknowledge clearance		E6	F1d		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Disengage ground maneuvering brake sys	E1				Discrete	Action
c	Engage ground maneuvering brake sys	E4			F3d	Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path			F2b		Intermit	Inform
b	Accelerate to taxi speed			F2b	F3e	Continu	
	1 Select speed increase target					Discrete	Decision
	2 Command forward thrust licrease					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed increase progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
c	Maintain taxi speed	E2		F3b	F3ef	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Decelerate to a stop	E4		F3c	F2c,3f	Continu	
	1 Select speed decrease target					Discrete	Decision
	2 Command forward thrust decrease					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
e	Alter heading 90 degrees right			F2b	F3bc	Continu	
	1 Select steering option					Discrete	Decision
	2 Command right turn					Discrete	Action
	3 Monitor indicated/commanded position					Intermit	Inform
	4 Evaluate turn progress					Intermit	Decision
	5 Modify steering commands as required					Intermit	Action
f	Maintain heading	E3		F3e	F3cd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify steering commands as required					Intermit	Action
F4	Manage Flight Plan						
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	End clearance acknow	00:05:15
	2	Attain 80 kts	
	3	Attain abort speed (146 kts)	
	4	Attain rotation speed (156 kts)	00:06:00
	5		
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.2.1	Segment:	Takeoff ground roll

Event/Function		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
⊕▽ ⊕▽ ⊕▽ ⊕▽								
	F1	Manage Flight Coordination						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<-■-x--■-x-■--x-■-x-■-x-■-x-■-x-■->	a	Monitor systems status					Intermit	Inform
<-■->	b	Disengage ground maneuvrng brake sys	E1				Discrete	Action
<-■->	c	Verify airspeed indication accuracy	E2				Descrete	Decision
	F3	Manage Aircraft Movement						
<--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Ground/Flight Path			F2b		Intermit	Inform
■■■■■■■■■■■■■■■■■■■■	b	Maintain heading			F2b	F3c	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify steering commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■	c	Accelerate to rotation speed			F2b	F3b	Continu	
		1 Select speed increase target					Descrete	Decision
		2 Command forward thrust increase					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed increase progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	F4	Manage Flight Plan						
<-■->	a	Initiate elapsed flight time measuremnt			F2b		Discrete	Action
	F5	Manage Contingencies						

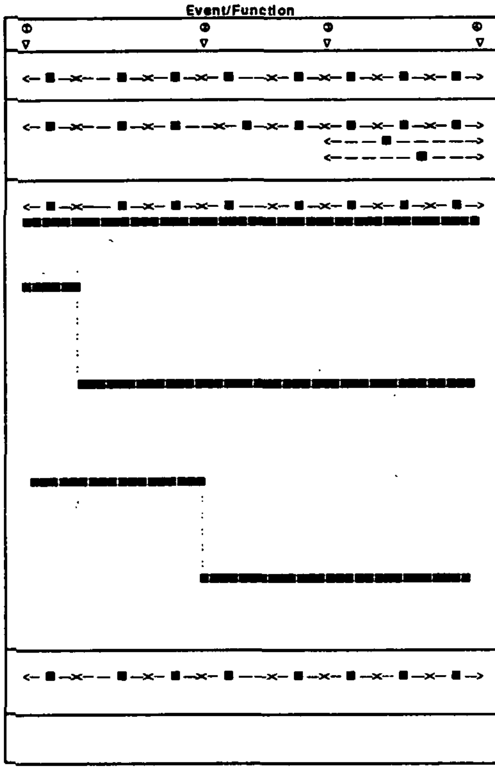
ANALYSIS FORMAT

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Attain rotation speed	00:06:00
	2	Attain climb speed	
	3	Attain stable flight	
	4	Arrive at 50 FT AGL	00:06:45
	5		
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.2.2	Segment:	Liftoff

Event/Function



		Function	Dependency Event Pro	Dependency Event Ret	Dependency Function Seq	Dependency Function Con	Performance Schedule	Performance Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Raise landing gear	E3	E4			Discrete	Action
	c	Disarm ground spoilers	E3	E4			Discrete	Action
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain heading				F3c-f	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	c	Rotate aircraft to takeoff attitude	E1			F3be	Continu	
		1 Select nose up attitude target					Discrete	Decision
		2 Command pitch up					Discrete	Action
		3 Monitor indicated/commanded attitude					Intermit	Inform
		4 Evaluate attitude change requirements					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
	d	Ascend to 50 FT AGL			F3c	F3bef	Continu	
		1 Select altitude increase target					Discrete	Decision
		2 Command pitch up attitude					Discrete	Action
		3 Monitor indicated/commanded altitude					Intermit	Inform
		4 Evaluate altitude increase progress					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
	e	Accelerate to climb speed (V2+10)	E1			F3bcd	Continu	
		1 Select speed increase target					Discrete	Decision
		2 Command Forward Thrust Increase					Discrete	Action
		3 Monitor Indicated/Commanded Speed					Intermit	Inform
		4 Evaluate Speed Increase Progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	f	Maintain climb speed	E2		F3e	F3bd	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

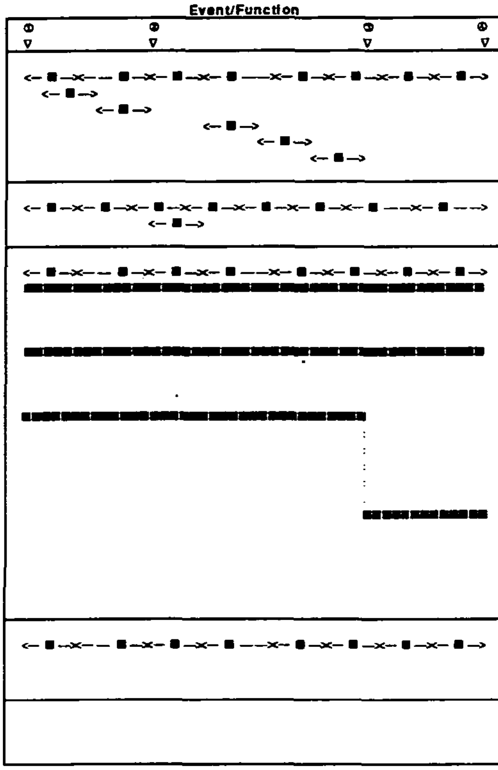
ANALYSIS FORMAT ✈

Symbol	Meaning
▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at 50 FT AGL	00:06:45
2	End freq change acknowledge	
3	End alt change acknowledge	
4	Arrive at 1500 MSL	00:07:30

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.2.3	Segment:	Initial Ascent

Event/Function



	Function	Dependency: Event Pro	Event Ret	Function Seq	Function Con	Performance: Schedule	Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive comm freq change					Discrete	Comm
c	Acknowledge comm freq change			F1ab		Discrete	Comm
d	Report airborne status			F2b		Discrete	Comm
e	Receive new alt clearance			F1d		Discrete	Comm
f	Acknowledge new alt clearance			F1e		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Tune LA departure control	E2		F1b		Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain climb speed				F3cde	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
c	Maintain Heading				F3bde	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
d	Ascend to 1500 FT MSL	E1			F3bc	Continu	
	1 Select altitude increase target					Discrete	Decision
	2 Command pitch up atitude					Discrete	Action
	3 Monitor indicated/commanded attitude					Intermit	Inform
	4 Evaluate altitude increase progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
e	Ascend to 13,000 FT MSL	E3		F3d	F3bc	Continu	
	1 Select altitude increase target					Discrete	Decision
	2 Command pitch up atitude					Discrete	Action
	3 Monitor Indicated/commanded attitude					Intermit	Inform
	4 Evaluate altitude increase progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at 1500 MSL	00:07:30
2	Cross LAX VORTAC	
3	Attain flap ret spd (176 kts)	
4	Attain slat ret spd (214 kts)	
5	Attain Vmm (250 kts)	00:08:00
6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.4	Segment:	Transition/acceleration

Event/Function ① ▽ ② ▽ ③ ▽ ④ ▽ ⑤ ▽		Function	Dependency: Event Pro	Ret	Function Seq	Con	Performance: Schedule	Category
	F1	Manage Flight Coordination						
<–■–x–– ■–x–■–x–■ ––x–■–x–■–x–■–x–■–>	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<–■–x–– ■–x–■–x–■ ––x–■–x–■–x–■–x–■–>	a	Monitor systems status					Intermit	Inform
<–■–>	b	Activate flight guidance/control system	E1				Discrete	Action
<–■–>	c	Retract flaps	E3				Discrete	Action
<–■–>	d	Retract slats	E4				Discrete	Action
	F3	Manage Aircraft Movement						
<–■–x–– ■–x–■–x–■ ––x–■–x–■–x–■–x–■–>	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■	b	Maintain Heading				F3cde	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
■■■■■■■■■■	c	Continue Ascent to 13,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude increase progress					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
■■	d	Maintain speed (V2+10)				F3bc	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
■■■■■■■■	e	Accelerate to 250 knots	E2		F3d	F3bc	Continu	
		1 Select speed increase target					Discrete	Decision
		2 Command forward thrust increase					Discrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed increase progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	F4	Manage Flight Plan						
<–■–x–– ■–x–■–x–■ ––x–■–x–■–x–■–x–■–>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Attain Vmm (250 kts)	00:08:00
2	Arrive at 3,000 FT MSL	00:09:00
3		
4		
5		
6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.2.5	Segment:	Ascent to 3,000 FT MSL

Event/Function		Function	Dependency: Event Pro	Ret	Function Seq	Con	Performance: Schedule	Category
	F1	Manage Flight Coordination						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<-■-x--■-x-■--x-■-x-■-x-■-x-■-x-■->	a	Monitor systems status					Intermit	Inform
<-■->	b	Activate bank angle limiting system	E1				Descrete	Action
	F3	Manage Aircraft Movement						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain Heading				F3cd	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	c	Continue Ascent to 13,000 FT MSL				F3bd	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude increase progress					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	d	Maintain speed (250 kts)	E1			F3bc	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify speed commands as required					Intermit	Action
	F4	Manage Flight Plan						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT

∇	Event
< >	Time Window
■	Time Duration

E	Event	Time
1	Arrive at 3,000 FT MSL	00:09:00
2	On course	
3	*End alt change acknow*	
4	Arrive at 10,000 FT MSL	00:11:00

1	Mission:	LAX to JFK
1.2	*Period:*	*Departure*
1.2.3	Phase:	Climb
1.2.3.1	Segment:	Ascent to 10,000 FT MSL

			Dependency				Performance	
			Event		Function			
		Function	Pro	Ret	Seq	Con	Schedule	Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	b	Receive new alt clearance					Discrete	Comm
	c	Acknowledge new alt clearance			F1b		Discrete	Comm
	d	Brief passengers on flight plan		E4			Discrete	Comm
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Activate auto throttle system	E1				Discrete	Action
	c	Access after takeoff checklist	E1				Discrete	Action
	d	Verify landing gear raised			F2c		Discrete	Decision
	e	Verify flaps retracted			F2c		Discrete	Decision
	f	Verify slats retracted			F2c		Discrete	Decision
	g	Verify spoilers disarmed			F2c		Discrete	Decision
	h	Deactivate auto braking system			F2c		Discrete	Action
	i	Verify external lights set as required			F2c		Discrete	Decision
	j	deact no smoking/seat belt warning sys			F2c		Discrete	Action
	k	Stow after takeoff checklist					Discrete	Action
	l	Reconfigure pneumatics system		E4	F2k		Discrete	Action
	m	Reconfigure air conditioning system		E4	F2k		Discrete	Action
	n	Reconfigure hydraulic system		E4	F2k		Discrete	Action
	o	Reconfigure fuel system		E4	F2k		Discrete	Action
	p	Reconfigure pressurization system					Discrete	Action
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain speed (250kts)				F3c-f	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	c	Turn to new heading	E1			F3be	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	d	Maintain heading	E2		F3c	F3bef	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as :equired					Intermit	Action
	e	Continue ascent to 13,000 FT MSL				F3bcd	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude increase progress					Intermit	Decision
		3 Modify pitch commands as required					*Intermit*	*Action*
	f	Ascend to 18,000 FT MSL	E3			F3bd	Continu	
		1 Select altitude increase target					Discrete	Decision
		2 Command pitch up attitude					Discrete	Action
		3 Monitor indicated/commanded altitude					Intermit	Inform
		4 Evaluate altitude increase progress					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

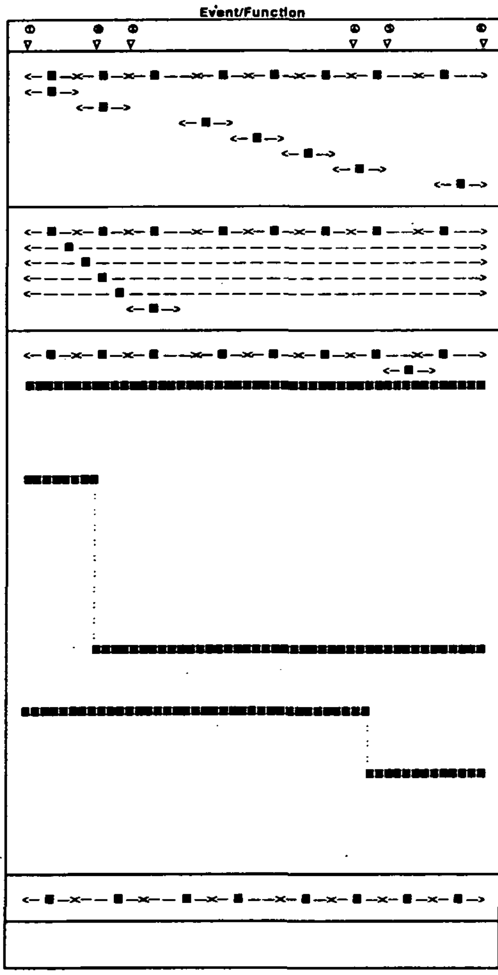
ANALYSIS FORMAT

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at 10,000 FT MSL	00:11:00
2	On course	
3	End freq change ack	
4	End alt change ack	
5	End traffic advisory	
6	Arrive at 18,000 FT MSL	00:15:12

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.3	Phase:	Climb
1.2.3.2	Segment:	Ascent to 18,000 FT MSL

Event/Function



	Function	Dependency: Event: Pro	Ret	Function: Seq	Con	Performance: Schedule	Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive comm freq change					Discrete	Comm
c	Acknowledge comm freq change			F1b		Discrete	Comm
d	Report position to LA center			F2f		Discrete	Comm
e	Receive new alt clearance			F1d		Discrete	Comm
f	Acknowledge new alt clearance			F1e		Discrete	Comm
g	Receive traffic advisory					Discrete	Comm
h	Report traffic sighting			F3a1		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Activate flight mgnt sys speed mode	E1				Discrete	Action
c	Deactivate main landing lights	E1	E6			Discrete	Action
d	Deactivate nose landing lights	E1	E6			Discrete	Action
e	Verify hi int recog lights activated	E1	E6			Discrete	Decision
f	Tune LA center	E3		F1b		Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
	1 Verify traffic location	E5		F1f		Discrete	Decision
b	Accelerate to cruise speed				F3c-f	Continu	
	1 Select speed increase target					Discrete	Decision
	2 Command forward thrust increase					Discrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed increase progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
c	Turn to new heading	E1			F3be	Continu	
	1 Select roll rates					Discrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command - left roll in					Discrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Discrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
d	Maintain Heading (SLI vortac)	E2		F3c	F3bef	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
e	Continue ascent to 18,000 FT MSL				F3bef	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude increase progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
f	Ascend to 23,000 FT MSL	E4		F3e	F3bd	Continu	
	1 Select altitude increase target					Discrete	Decision
	2 Command pitch up attitude					Discrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude increase progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at 18,000 FT MSL	00:15:12
	2	Cross SLI vortac	00:17:42
	3		
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.3	Phase:	Climb
1.2.3.3	Segment:	Ascent to wpt SLI vortac

Event/Function ① ▽ … ② ▽		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
	F1	Manage Flight Coordination						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<– ■–x–– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–x– ■–>	a	Monitor systems status					Intermit	Inform
<– ■–>	b	Adjust altimeters	E1				Discrete	Action
	F3	Manage Aircraft Movement						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■■■■■■■	b	Maintain heading (SLI vortac)				F3cd	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
■■■■■■■■■■■■■■■■	c	Continue ascent to 23,000 FT MSL				F3bd	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude increase progress					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
■■■■■■■■■■■■■■■■	d	Continue acceleration to cruise speed				F3bc	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed increase progress					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	F4	Manage Flight Plan						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Cross SLI vortac	00:17:42
2	On course	
3	End comm freq change ack	
4	End alt change acknow	
5	Cross TRM vortac	00:26:06

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.3	Phase:	Climb
1.2.3.4	Segment:	Ascent to wpt TRM vortac

Event/Function

	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive comm freq change					Discrete	Comm
c	Acknowledge comm freq change			F1b		Discrete	Comm
d	Report position to LA center			F2b		Discrete	Comm
e	Receive new alt clearance			F1d		Discrete	Comm
f	*Acknowledge new alt clearance*			F1e		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Tune LA center	E3		F1c		Discrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Continue acceleration to cruise speed				F3c-f	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed increase progress					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
c	*Turn to new heading*	E1			F3be	Continu	
	1 Select roll rates					Discrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command left roll in					Discrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Discrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
d	Maintain heading (TRM vortac)	E2		F3c	F3bef	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
e	Continue ascent to 23,000 FT MSL				F3bcd	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude increase progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
f	Ascend to 33,000 FT MSL	E4		F3e	F3bd	Continu	
	1 Select altitude increase target					Discrete	Decision
	2 Command pitch up attitude					Discrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude increase progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

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C-3

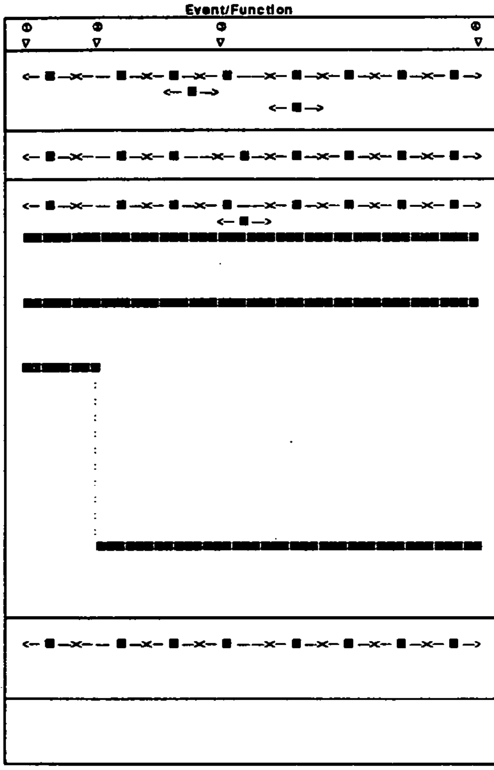
ANALYSIS FORMAT

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross TRM vortac	00:26:06
	2	On course	
	3	End traffic advisory	
	4	Cross TNP vortac	00:29:48
	5		
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.3	Phase:	Climb
1.2.3.5	Segment:	Ascent to wpt TNP vortac

Event/Function



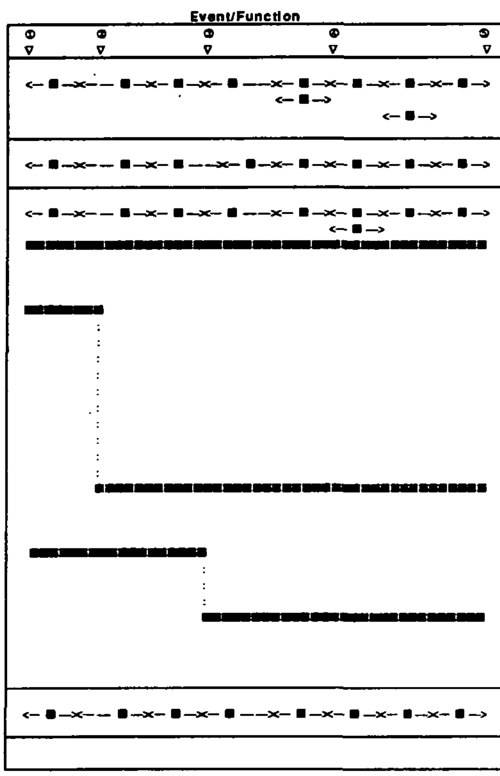
	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive traffic advisory					Discrete	Comm
c	Report traffic sighting			F3a1		Discrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
	1 Verify traffic location	E3		F1b		Discrete	Decision
b	Continue ascent to 33,000 FT MSL				F3cde	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude increase progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
c	Continue acceleration to cruise speed				F3bde	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed increase progress					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Turn to new heading	E1			F3bc	Continu	
	1 Select roll rates					Discrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command left roll in					Discrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Discrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
e	Maintain heading (TNP vortac)	E2		F3d	F3bc	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT

- ∇ Event
- < > Time Window
- ■ Time Duration

		Event	Time
E	1	Cross TNP vortac	00:29:48
	2	On course	
	3	Cruise speed	
	4	End traffic advisory	
	5	Arrive at 33,000 FT MSL	00:34:12
	6		

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.3	Phase:	Climb
1.2.3.6	Segment:	Ascent to cruise altitude



			Dependency				Performance	
			Event		Function			
		Function	Pro	Ret	Seq	Con	Schedule	Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	b	Receive traffic advisory					Descrete	Comm
	c	Report traffic sighting			F3a1		Descrete	Comm
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
		1 Verify traffic location	E4		F1b		Descrete	Decision
	b	Continue ascent to 33,000 FT MSL				F3c-f	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude increase progress					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Turn to new heading	E1			F3be	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	d	Maintain heading (DRK vortac)	E2		F3c	F3bef	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	e	Continue acceleration to cruise speed				F3bcd	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed increase progress					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	f	Maintain cruise speed	E3		F3e	F3bd	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at 33,000 FT MSL	00:34:12
	2	End comm freq change ack	
	3	Cross DRK vortac	00:55:12
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.1	Segment:	Flight to wpt DRK vortac

Event/Function ① ▽ ② ▽ ③ ▽		Function	Dependency Event Pro	Ret	Function Seq	Con	Performance Schedule	Category
	F1	Manage Flight Coordination						
<–■–x––■–x–■–x–■––x–■–x–■–x–■–x–■–>	a	Monitor Partyline					Intermit	Inform
<–■–>	b	Receive comm freq change					Discrete	Comm
<–■–>	c	Acknowledge comm freq change			F1b		Discrete	Comm
<–■–>	d	Report aircraft position			F2b		Discrete	Comm
<–■–>	e	Receive identification request			F1d		Discrete	Comm
<–■–>	f	Transmit aircraft identification			F1e		Discrete	Comm
	F2	Manage Aircraft Systems/Procedures						
<–■–x––■–x–■––x–■–x–■–x–■–x–■–x–■–>	a	Monitor systems status					Intermit	Inform
<–■–>	b	Tune ABQ center			F1c		Discrete	Action
	F3	Manage Aircraft Movement						
<–■–x––■–x–■–x–■––x–■–x–■–x–■–x–■–>	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■■■■■■■■■■■■■■■	b	Maintain altitude at 33,000 FT MSL	E1			F3cd	Continu	
		3 Monitor indicated/commanded altitude					Intermit	Inform
		4 Evaluate altitude change requirements					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■■■■■	c	Maintain cruise speed				F3bd	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■■■■■	d	Maintain heading (DRK vortac)				F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
<–■–x––■–x–■–x–■––x–■–x–■–x–■–x–■–>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

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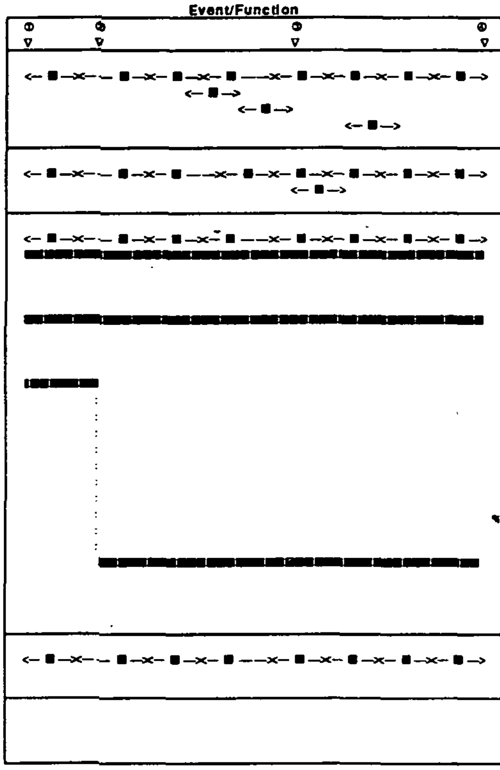
ANALYSIS FORMAT →

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross DRK vortac	00:55:12
	2	On course	
	3	End comm freq change ack	
	4	Cross GUP vortac	01:18:12
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.2	Segment:	Flight to wpt GUP vortac

Event/Function



		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	b	Receive comm freq change					Discrete	Comm
	c	Acknowledge comm freq change			F1b		Discrete	Comm
	d	Report aircraft position			F2b		Discrete	Comm
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Tune cleveland center			F1c		Discrete	Action
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (GUP vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

ANALYSIS FORMAT ✈

Symbol	Meaning
▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Cross GUP vortac	01:18:12
2	On course	
3	Cross CIM vortac	01:43:54
4		
5		
6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.3	Segment:	Flight to wpt CIM vortac

Event/Function

		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (CIM vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

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ANALYSIS FORMAT ✈

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross CIM vortac	01:43:54
	2	On course	
	3	Cross LBL vortac	02:07:54
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.4	Segment:	Flight to wpt LBL vortac

Event/Function			Dependency				Performance	
① ① ①			Event		Function			
∇ ∇ ∇		Function	Pro	Ret	Seq	Con	Schedule	Category
	F1	Manage Flight Coordination						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<– ■ –x– – ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (LBL vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT

Symbol	Meaning
∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross LBL vortac	02:07:54
	2	On course	
	3	Cross ICT vortac	02:28:54
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.5	Segment:	Flight to wpt ICT vortac

Event/Function			Function	Dependency Event Pro	Dependency Event Ret	Dependency Function Seq	Dependency Function Con	Performance Schedule	Performance Category
	F1		Manage Flight Coordination						
		a	Monitor Partyline					Intermit	Inform
	F2		Manage Aircraft Systems/Procedures						
		a	Monitor systems status					Intermit	Inform
	F3		Manage Aircraft Movement						
		a	Monitor Ground/Flight Path					Intermit	Inform
		b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
			1 Monitor indicated/commanded altitude					Intermit	Inform
			2 Evaluate altitude change requirements					Intermit	Decision
			3 Modify pitch commands as required					Intermit	Action
		c	Maintain cruise speed				F3bde	Continu	
			1 Monitor indicated/commanded speed					Intermit	Inform
			2 Evaluate speed change requirements					Intermit	Decision
			3 Modify thrust commands as required					Intermit	Action
		d	Turn to new heading	E1			F3bc	Continu	
			1 Select roll rates					Discrete	Decision
			2 Monitor for roll in cue					Intermit	Inform
			3 Command left roll in					Discrete	Action
			4 Monitor indicated/commanded roll rate					Intermit	Inform
			5 Evaluate turn progress					Intermit	Decision
			6 Modify roll rate as required					Intermit	Action
			7 Monitor for roll out cue					Intermit	Inform
			8 Command right roll out					Discrete	Action
			9 Evaluate recovery progress					Intermit	Decision
			10 Modify roll rate as required					Intermit	Action
		e	Maintain heading (ICT vortac)	E2		F3d	F3bc	Continu	
			1 Monitor indicated/commanded heading					Intermit	Inform
			2 Evaluate heading change requirements					Intermit	Decision
			3 Modify roll commands as required					Intermit	Action
	F4		Manage Flight Plan						
		a	Monitor flight progress					Intermit	Inform
	F5		Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Cross ICT vortac	02:28:54
2	On course	
3	Cross BUM vortac	02:47:48
4		
5		
6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.6	Segment:	Flight to wpt BUM vortac

Event/Function

	Function	Dependency: Event: Pro	Dependency: Event: Ret	Dependency: Function: Seq	Dependency: Function: Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
c	Maintain cruise speed				F3bde	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Turn to new heading	E1			F3bc	Continu	
	1 Select roll rates					Discrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command right roll in					Discrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command left roll out					Discrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
e	Maintain heading (BUM vortac)	E2		F3d	F3bc	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Cross BUM vortac	02:47:48
2	On course	
3	Cross STL vortac	03:12:00
4		
5		
6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.7	Segment:	Flight to wpt STL vortac

Event/Function

			Dependency				Performance	
			Event		Function			
		Function	Pro	Ret	Seq	Con	Schedule	Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (STL vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
F5		Manage Contingencies						

ANALYSIS FORMAT ✈

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross STL vortac	03:12:00
	2	On course	
	3	Cross VHP vortac	03:37:12
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.8	Segment:	Flight to wpt VHP vortac

Event/Function ⊕∇ ⊕∇ ⊕∇		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
	F1	Manage Flight Coordination						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<– ■ –x– – ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (VHP vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
<– ■ –x– – ■ –x– ■ –x– ■ ––x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross VHP vortac	03:37:12
	2	On course	
	3	Cross CREEP intersection	03:49:12
	4		
	5		
	6		

1	Mission: LAX to JFK
1.3	Period: Enroute
1.3.1	Phase: Cruise
1.3.1.9	Segment Flight to wpt CREEP Intersct

Event/Function ▽ ▽ ▽		Function	Dependency Event Pro	Ret	Function Seq	Con	Performance Schedule	Category
	F1	Manage Flight Coordination						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<– ■–x–– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–x– ■–>	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■■■■■■■■■■■	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
■■■■	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
■■■■■■■■■■■■■■■■	e	Maintain heading (CREEP intersection)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
<– ■–x–– ■–x– ■–x– ■ ––x– ■–x– ■–x– ■–x– ■–>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT →

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross CREEP intersection	03:49:12
	2	On course	
	3	Cross AIR vortac	04:09:30
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.10	Segment:	Flight to wpt AIR vortac

Event/Function			Dependency				Performance	
⊕ ⊕ ⊕			Event		Function			
▽ ▽ ▽		Function	Pro	Ret	Seq	Con	Schedule	Category
	F1	Manage Flight Coordination						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
<-■-x--■-x-■--x-■-x-■-x-■-x-■-x-■->	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■■■■■■■■■■■	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
■■■■	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command left roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command right roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
■■■■■■■■■■■■■■■■	e	Maintain heading (AIR vortac)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
<-■-x--■-x-■-x-■--x-■-x-■-x-■-x-■->	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross AIR vortac	04:09:30
	2	On course	
	3	Cross BOGGE intersection	04:29:54
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.11	Segment:	Flight to wpt BOGGE Intersct

Event/Function			Dependency				Performance	
			Event		Function			
		Function	Pro	Ret	Seq	Con	Schedule	Category
	F1	Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	F2	Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3cde	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Maintain cruise speed				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	d	Turn to new heading	E1			F3bc	Continu	
		1 Select roll rates					Discrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command roll in					Discrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command roll out					Discrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	e	Maintain heading (BOGGE intersection)	E2		F3d	F3bc	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	F4	Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross BOGGE intersection	04:29:54
	2	On course	
	3	End comm freq change ack	
	4	Arrive at deceleration point	
	5	Arrive at top of descent	04:33:18
	6		

1	Mission:	LAX to JFK
1.3	Period:	Enroute
1.3.1	Phase:	Cruise
1.3.1.12	Segment:	Flight to top of descent

Event/Function ① ▽ ② ▽ ③ ▽ ④ ▽ ⑤ ▽		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
	F1	Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	b	Receive comm freq change					Descrete	Comm
	c	Acknowledge comm freq change			F1b		Descrete	Comm
	d	Report aircraft position			F2b		Descrete	Comm
	e	Receive descent clearance			F1d		Descrete	Comm
	f	Acknowledge descent clearance			F1e		Descrete	Comm
	g	Transmit aircraft identity			F1f		Descrete	Comm
	F2	Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Tune new york center			F1c		Descrete	Action
	F3	Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain altitude at 33,000 FT MSL				F3c-f	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	c	Turn to new heading	E1			F3bef	Continu	
		1 Select roll rates					Descrete	Decision
		2 Monitor for roll in cue					Intermit	Inform
		3 Command roll in					Descrete	Action
		4 Monitor indicated/commanded roll rate					Intermit	Inform
		5 Evaluate turn progress					Intermit	Decision
		6 Modify roll rate as required					Intermit	Action
		7 Monitor for roll out cue					Intermit	Inform
		8 Command roll out					Descrete	Action
		9 Evaluate recovery progress					Intermit	Decision
		10 Modify roll rate as required					Intermit	Action
	d	Maintain heading (COPES intersection)	E2		F3c	F3bef	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	e	Maintain cruise speed				F3bcd	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	f	Decelerate to descent speed	E4		F3e	F3bd	Continu	
		1 Select speed decrease target					Descrete	Decision
		2 Command forward thrust decrease					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed decrease progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	F4	Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

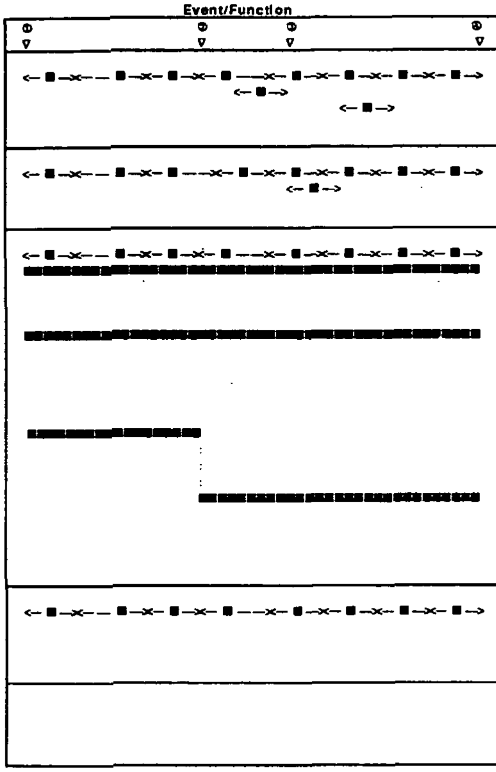
ANALYSIS FORMAT →

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at top of descent	04:33:18
	2	Attain descent speed	
	3	End of traffic advisory	
	4	Arrive at 25,000 FT MSL	04:36:30
	5		
	6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.1	Segment:	Descent to 25,000 FT MSL

Event/Function



	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive traffic advisory					Descrete	Comm
c	Report traffic sighting			F2b		Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Verify traffic location	E3		F1c		Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain Heading (COPES intersection)				F3cde	Continu	
	1 Monitor indicated/Commanded Heading					Intermit	Inform
	2 Evaluate Heading Change Requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
c	Descend to 25,000 FT MSL	E1			F3bde	Continu	
	1 Select altitude decrease target					Descrete	Decision
	2 Command pitch down					Descrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude decrease progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
d	Continue deceleration to descent speed	E1			F3bc	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed decrease progress					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
e	Maintain descent speed (310 kts)	E2		F3d	F3bc	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5.	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at 25,000 FT MSL	04:36:30
2	End alt change acknow	
3	Arrive at 18,000 FT MSL	04:39:24
4		
5		
6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.2	Segment:	Descent to 18,000 FT MSL

Event/Function			Dependency				Performance	
① ② ③			Event		Function			
▽ ▽ ▽		Function	Pro	Ret	Seq	Con	Schedule	Category
	F1	Manage Flight Coordination						
<– ■ –x– – ■ –x– ■ –x– ■ ——x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Partyline					Intermit	Inform
<– ■ –>	b	Receive new alt clearance					Descrete	Comm
<– ■ –>	c	Acknowledge new alt clearance			F1b		Descrete	Comm
	F2	Manage Aircraft Systems/Procedures						
<– ■ –x– – ■ –x– ■ –x– ■ ——x– ■ –x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor systems status					Intermit	Inform
	F3	Manage Aircraft Movement						
<– ■ –x– – ■ –x– ■ –x– ■ ——x– ■ –x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor Ground/Flight Path					Intermit	Inform
■■■■■■■■■■■■■■■■■■■■	b	Maintain heading (COPES intersection)				F3cde	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
■■■■■■■■■■■■■■■■■■■■	c	Maintain 310 kts				F3bde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
■■■■■	d	Maintain altitude at 25,000 FT MSL				F3bc	Continu	
:		1 Monitor indicated/commanded altitude					Intermit	Inform
:		2 Evaluate altitude change requirements					Intermit	Decision
:		3 Modify pitch commands as required					Intermit	Action
■■■■■■■■■■■■■■■	e	Descend to 13,000 FT MSL	E2		F3d	F3bc	Continu	
		1 Select altitude decrease target					Descrete	Decision
		2 Command pitch down increase					Descrete	Action
		3 Monitor indicated/commanded altitude					Intermit	Inform
		4 Evaluate altitude decrease progress					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
	F4	Manage Flight Plan						
<– ■ –x– – ■ –x– ■ –x– ■ ——x– ■ –x– ■ –x– ■ –x– ■ –>	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at 18,000 FT MSL	04:39:24
	2	Arrive at 13,000 FT MSL	04:42:18
	3		
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.3	Segment:	Descent to 13,000 FT MSL

		Dependency				Performance	
		Event		Function			
	Function	Pro	Ret	Seq	Con	Schedule	Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive weather/visibility info		E2	F2c		Descrete	Comm
c	Brief crew on approach/landing procdrs		E2			Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Adjust altimeters for local pressure	E1				Descrete	Action
c	Tune JFK ATIS	E1				Descrete	Action
d	Access descent/approach checklist			F2b		Descrete	Action
e	Verify normal approach speeds			F2d		Descrete	Decision
f	Set anti-ice system as reqd			F2d		Descrete	Action
g	Select decision height			F2d		Descrete	Decision
h	Set passenger warning sys as reqd			F2d		Descrete	Action
i	Verify altimeters set for baro pressure			F2d		Descrete	Decision
j	Verify radios set as required			F2d		Descrete	Decision
k	Verify electrnc display sys set as reqd			F2d		Descrete	Decision
l	Reconfigure hydraulic system			F2d		Descrete	Action
m	Stow descent/approach checklist		E2			Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain heading (COPES intersection)				F3cd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
c	Maintain 310 kts				F3bd	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Continue descent to 13,000 FT MSL				F3bc	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude decrease progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						
a	Prepare for missed approach						
	1 Select missed approach runway			F2d		Descrete	Decision
	2 Select missed approach speed			F2d		Descrete	Decision

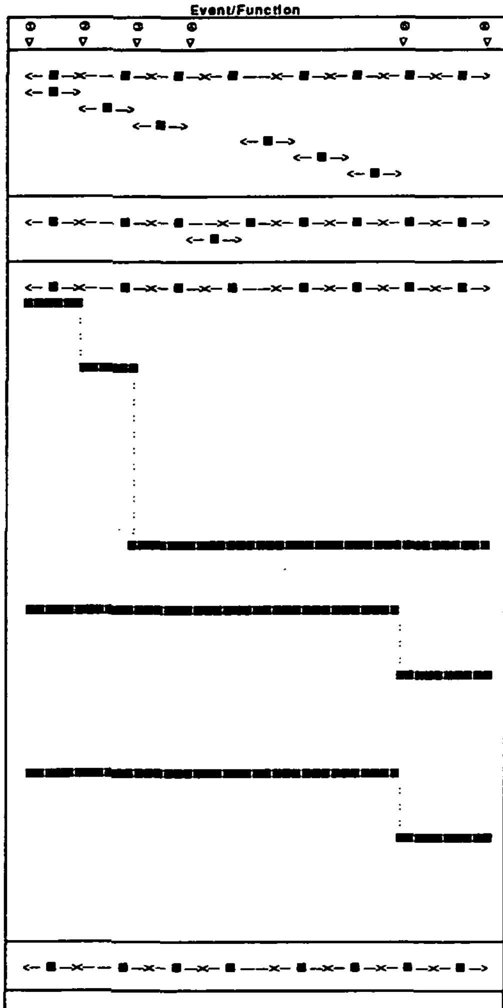
ANALYSIS FORMAT ✈

∇	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at 13,000 FT MSL	04:42:18
2	Cross COPES intersection	
3	On course	
4	End comm freq change ack	
5	End apprch instructions ack	
6	Arrive at 10,000 FT MSL	04:45:12

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.4	Segment:	Descent to 10,000 FT MSL

Event/Function



		Dependency: Event		Dependency: Function		Performance	
	Function	Pro	Ret	Seq	Con	Schedule	Category
F1	Manage Flight Coordination						
a	*Monitor Partyline*					*Intermit*	*Inform*
b	Report aircraft position					Descrete	Comm
c	Receive comm freq change			F1b		Descrete	Comm
d	Acknowledge comm freq change			F1c		Descrete	Comm
e	Transmit aircraft identity			F2b		Descrete	Comm
f	Receive approach instructions			F1e		Descrete	Comm
g	Acknowledge approach instructions			F1f		Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Tune New York approach			F1d		Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain Heading (COPES intersection)				F3eg	Continu	
	1 Monitor indicated/Commanded Heading					Intermit	Inform
	2 Evaluate Heading Change Requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
c	Turn to new heading	E2		F3b	F3eg	Continu	
	1 Select roll rates					Descrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					*Intermit*	*Action*
d	Maintain Heading (RBV vortac)	E3		F3c	F3e-h	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commends as required					Intermit	Action
e	Maintain altitude at 13,000 FT MSL				F3bcdg	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
f	Descend to 5,000 FT MSL	E5		F3e	F3dh	Continu	
	1 Select altitude decrease target					Descrete	Decision
	2 Command pitch down					Descrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude decrease progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
g	Maintain 310 kts				F3b-e	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
h	Decelerate to 250 kts	E5		F3g	F3df	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command forward thrust decrease					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

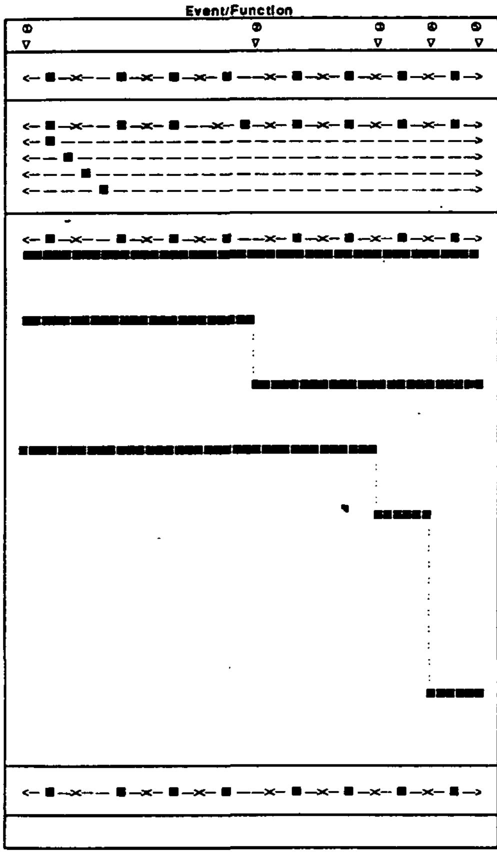
ANALYSIS FORMAT →

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at 10,000 FT MSL	04:45:12
	2	Attain 250 kts	
	3	Cross RBV vortac	
	4	On course	
	5	Arrive at 5,000 FT MSL	04:48:06
	6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.5	Segment:	Descent to 5,000 FT MSL

Event/Function



	Function	Dependency Event Pro	Dependency Event Ret	Dependency Function Seq	Dependency Function Con	Performance Schedule	Performance Category
F1	Manage Flight Coordination						
a	Monitor Partyline	.				Intermit	Inform
F2	Manage Aircraft Systems/Procedures						
a	Monitor systeme status					Intermit	Inform
b	Activate main landing lights	E1	E5			Descrete	Action
c	Activate nose taxi lights	E1	E5			Descrete	Action
d	Activate wing lights	E1	E5			Descrete	Action
e	Verify hi int recog lights activated	E1	E5			Descrete	Decision
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Continue descent to 5,000 FT MSL				F3c-g	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude decrease progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
c	Continue deceleration to 250 kts				F3be	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed decrease progress					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Maintain 250 kts	E2		F3c	F3befg	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
e	Maintain heading (RBV vortac)				F3bcd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
f	Turn to new heading	E3		F3e	F3bd	Continu	
	1 Select roll rates					Descrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
g	Maintain heading (COL vortac)	E4		F3f	F3bd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at 5,000 FT MSL	04:48:06
	2	End apprch instructs ack	
	3	Cross COL vortac	
	4	On course	
	5	End apprch instructs ack	
	6	Attain 200 kts	
	7	Arrive at 2000 FT MSL	
	8	Cross Initial aprch fix	04:51:00

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.1	Phase:	Descent
1.4.1.6	Segment:	Descent to initial aprch fix

Event/Function

	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Report aircraft position					Descrete	Comm
c	Receive approach instructions			F1b		Descrete	Comm
d	Acknowledge approach instructions			F1c		Descrete	Comm
e	Receive approach instructions					Descrete	Comm
f	Acknowledge approach instructions			F1e		Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain heading (COL vortac)				F3efh	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
c	Turn to new heading (100 deg)	E3		F3b	F3fh	Continu	
	1 Select roll rates					Descrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command right roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command left roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
d	Maintain heading (IAF)	E4		F3c	F3f-j	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
e	Maintain altitude at 5,000 FT MSL	E1			F3bh	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
f	Descend to 2,000 FT MSL	E2		F3e	F3bcdhij	Continu	
	1 Select altitude decrease target					Descrete	Decision
	2 Command pitch down					Descrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude decrease progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
g	Maintain altitude at 2,000 FT MSL	E7			F3dj	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
h	Maintain 250 kts				F3b-f	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
i	Decelerate to 200 kts	E5		F3h	F3df	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command forward thrust decrease					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
j	Maintain 200 kts	E6		F3i	F3dfg	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
<>	Time Window
■	Time Duration

	Event	Time
E 1	Cross initial aprch fix	04:51:00
2	On course	
3	Attain 180 kts	
4	Attain 155 kts	
5	End aprch instructs ack	
6	Cross intermed aprch fix	04:55:12

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.2	Phase:	Approach
1.4.2.1	Segment:	Descent to Interm aprch fix

	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Receive approach instructions					Descrete	Comm
c	Acknowledge approach instructions			F1b		Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Tune JFK ILS					Descrete	Action
c	Extend slats	E3				Descrete	Action
d	Extend flaps to 28 degress			F2c		Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Turn to new heading (048 deg)	E1			F3dl	Continu	
	1 Select roll rates					Descrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command left roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
c	Maintain heading (048 deg)	E2		F3b	F3d-l	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
d	Maintain 200 kts				F3bcl	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
e	Decelerate to 180 kts			F3d	F3cl	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command forward thrust decrease					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
f	Maintain 180 kts	E3		F3e	F3cl	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
g	Decelerate to 155 kts			F3f	F3cl	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command forward thrust decrease					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
h	Maintain 155 kts	E4		F3g	F3cij	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
i	Maintain altitude at 2,000 FT MSL				F3b-h	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
j	Descend to 1900 FT MSL	E5		F3i	F3ch	Continu	
	1 Select altitude decrease target					Descrete	Decision
	2 Command pitch down					Descrete	Action
	3 Monitor indicated/commanded altitude					Intermit	Inform
	4 Evaluate altitude decrease progress					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	*Manage Contingencies*						

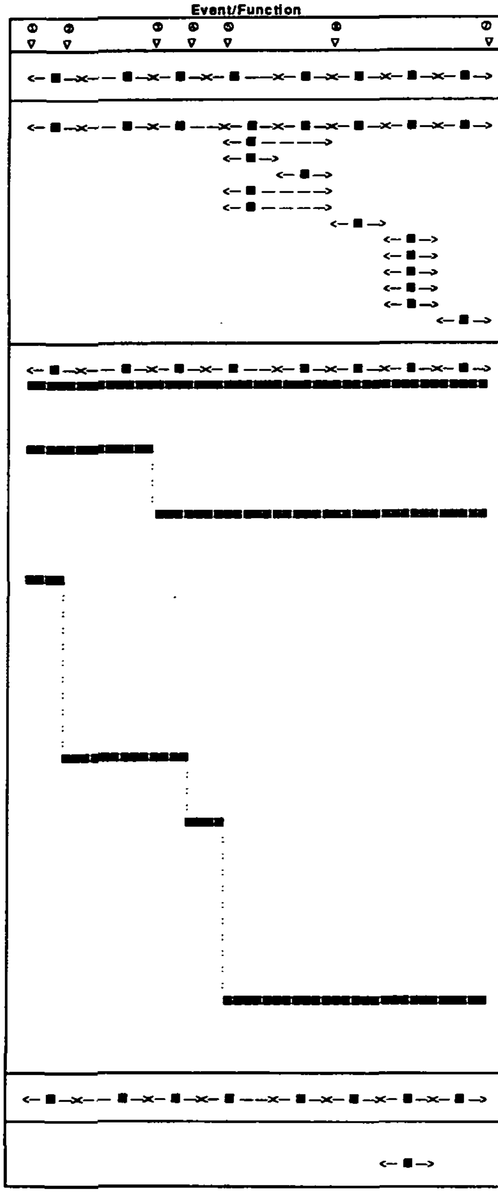
ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Cross intermed aprch fix	04:55:12
2	On course	
3	Arrive at 1900 FT MSL	
4	Cross final aprch fix	
5	On course/localizer	
6	Intercept glide slope	
7	Cross outer marker	04:59:06

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.2	Phase:	Approach
1.4.2.2	Segment:	Descent to outer marker

Event/Function



	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
b	Lower landing gear	E5				Descrete	Action
c	Extend flaps to 35 degrees					Descrete	Action
d	Extend flaps to 50 degrees			F2c		Descrete	Action
e	Verify ground maneuv brake sys ok					Descrete	Decision
f	Arm spoilers for landing					Descrete	Action
g	Access before landing checklist					Descrete	Action
h	Verify landing gear lowered			F2g		Descrete	Decision
i	Verify emergency braking sys armed			F2g		Descrete	Decision
j	Verify spoilers armed			F2g		Descrete	Decision
k	verify flaps/slats extended for landing			F2g		Descrete	Decision
l	Verify altimeters set for local pressure			F2g		Descrete	Decision
m	Stow before landing checklist		E7			Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain 155 kts				F3c-h	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
c	Continue descent to 1900 FT MSL				F3be-h	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude decrease progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
d	Maintain altitude at 1900 FT MSL	E5		F3c		Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude change requirements					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
e	Turn to new heading (005 deg)	E1			F3bc	Continu	
	1 *Select roll rates*					*Descrete*	*Decision*
	2 Monitor for roll in cue					Intermit	Inform
	3 Command left roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
f	Maintain heading (005 deg)	E2		F3e	F3bcd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
g	Turn to new heading (313 deg)	E3		F3f	F3bd	Continu	
	1 Select roll rates					Descrete	Decision
	2 Monitor for roll in cue					Intermit	Inform
	3 Command left roll in					Descrete	Action
	4 Monitor indicated/commanded roll rate					Intermit	Inform
	5 Evaluate turn progress					Intermit	Decision
	6 Modify roll rate as required					Intermit	Action
	7 Monitor for roll out cue					Intermit	Inform
	8 Command right roll out					Descrete	Action
	9 Evaluate recovery progress					Intermit	Decision
	10 Modify roll rate as required					Intermit	Action
h	Maintain heading (aprch runway)	E4		F3g	F3bd	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 *Modify roll commands as required*					*Intermit*	*Action*
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						
a	Prepare for missed approach						
	1 Select missed aprch recovery altitude			F2g		Descrete	Decision

ANALYSIS FORMAT ✈

Symbol	Meaning
▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross outer marker	04:59:06
	2	End landing clearance ack	
	3	Cross middle marker	
	4	Arrive at decision height	05:00:48
	5		
	6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.3	Phase:	Land
1.4.3.1	Segment:	Descent to decision height

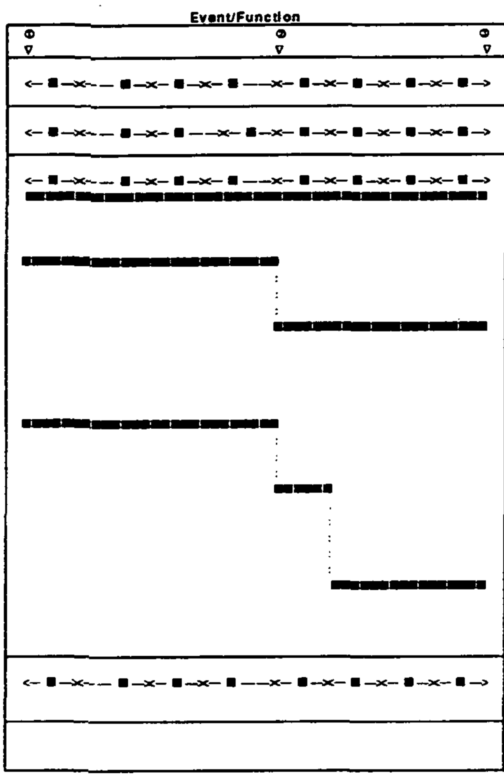
Event/Function		Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
	F1	Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
	b	Report aircraft position			F2b		Descrete	Comm
	c	Receive landing clearance			F1b		Descrete	Comm
	d	Acknowledge landing clearance			F1c		Descrete	Comm
	F2	Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Tune JFK tower	E1				Descrete	Action
	F3	Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain 155 kias				F3cde	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	c	Maintain heading (approach runway)				F3bde	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	d	Maintain altitude at 1900 FT MSL				F3bc	Continu	
		1 Monitor indicated/commanded altitude					Intermit	Inform
		2 Evaluate altitude change requirements					Intermit	Decision
		3 Modify pitch commands as required					Intermit	Action
	e	Descend to 100 FT MSL	E2		F3d	F3bc	Continu	
		1 Select altitude decrease target					Descrete	Decision
		2 Command pitch down					Descrete	Action
		3 Monitor indicated/commanded altitude					Intermit	Inform
		4 Evaluate altitude decrease progress					Intermit	Decision
		5 Modify pitch commands as required					Intermit	Action
	F4	Manage Flight Plan						
	a	Monitor flight progress					Intermit	Inform
	F5	Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at decision height	05:00:48
	2	Arrive at 100 FT MSL	
	3	Main gear touch down	05:03:30
	4		
	5		
	6		

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.3	Phase:	Land
1.4.3.2	Segment:	Descent to touch down



	Function	Dependency: Event Pro	Dependency: Event Ret	Dependency: Function Seq	Dependency: Function Con	Performance: Schedule	Performance: Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
F2	Manage Aircraft Systems/Procedures						
a	Monitor systems status					Intermit	Inform
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain heading (approach runway)				F3c-g	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify roll commands as required					Intermit	Action
c	Maintain 155 kts				F3be	Continu	
	1 Monitor indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
d	Decelerate to touchdown speed	E2		F3c	F3bfg	Continu	.
	1 Select speed decrease target					Descrete	Decision
	2 Command idle forward thrust					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
e	Continue descent to 100 FT MSL				F3bc	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude decrease progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
f	Rotate a/c to landing attitude (flare)	E2		F3e	F3bd	Continu	
	1 Select nose up attitude target					Descrete	Decision
	2 Command pitch up					Descrete	Action
	3 Monitor indicated/commanded attitude					Intermit	Inform
	4 Evaluate attitude change requirements					Intermit	Decision
	5 Modify pitch commands as required					Intermit	Action
g	Descend to touchdown			F3f	F3bd	Continu	
	1 Monitor indicated/commanded altitude					Intermit	Inform
	2 Evaluate altitude decrease progress					Intermit	Decision
	3 Modify pitch commands as required					Intermit	Action
F4	Manage Flight Plan						
a	Monitor flight progress					Intermit	Inform
F5	Manage Contingencies						

ANALYSIS FORMAT →

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Main gear touch down	05:03:30
	2	Nose gear touch down	
	3	Attain 80 knots	
	4	Attain 60 knots	
	5	Aircraft stopped	
	6	Attain taxi speed	
	7	Arrive at runway threshold	05:04:30

1	Mission:	LAX to JFK
1.4	Period:	Arrival
1.4.3	Phase:	Land
1.4.3.3	Segment:	Landing ground roll

Event/Function

			Dependency				Performance	
			Event		Function			
		Function	Pro	Ret	Seq	Con	Schedule	Category
F1		Manage Flight Coordination						
	a	Monitor Partyline					Intermit	Inform
F2		Manage Aircraft Systems/Procedures						
	a	Monitor systems status					Intermit	Inform
	b	Engage ground maneuv brake system				F2c	Descrete	Action
	c	Deploy spoilers				F2b	Descrete	Action
	d	Stow spoilers					Descrete	Action
	e	Deactivate auto pilot system					Descrete	Action
	f	Disengage ground maneuv brake system					Descrete	Action
F3		Manage Aircraft Movement						
	a	Monitor Ground/Flight Path					Intermit	Inform
	b	Maintain Heading (approach runway)				F3d	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify roll commands as required					Intermit	Action
	c	Maintain heading (approach runway)	E2		F3b	F3d-i	Continu	
		1 Monitor indicated/commanded heading					Intermit	Inform
		2 Evaluate heading change requirements					Intermit	Decision
		3 Modify steering commands as required					Intermit	Action
	d	Continue deceleration to touchdown spd				F3b	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed decrease progress					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
	e	Decelerate to 80 knots	E2		F3d	F3c	Continu	
		1 Select speed decrease target					Descrete	Decision
		2 Command full reverse thrust					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed decrease progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	f	Decelerate to 60 knots	E3		F3e	F3c	Continu	
		1 Select speed decrease target					Descrete	Decision
		2 Command reverse idle thrust					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed decrease progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	g	Decelerate to a complete stop	E4		F3f	F3c	Continu	
		1 Select speed decrease target					Descrete	Decision
		2 Command forward idle thrust					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed decrease progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	h	Accelerate to taxi speed			F2f	F3c	Continu	
		1 Select speed increase target					Descrete	Decision
		2 Command forward thrust increase					Descrete	Action
		3 Monitor indicated/commanded speed					Intermit	Inform
		4 Evaluate speed increase progress					Intermit	Decision
		5 Modify thrust commands as required					Intermit	Action
	i	Maintain taxi speed	E6		F3h	F3c	Continu	
		1 Monitor indicated/commanded speed					Intermit	Inform
		2 Evaluate speed change requirements					Intermit	Decision
		3 Modify thrust commands as required					Intermit	Action
F4		Manage Flight Plan						
	a	Terminate elapsed flight time measurem	E5				Descrete	Action
F5		Manage Contingencies						

ANALYSIS FORMAT ✈

▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Arrive at runway threshold	05:04:30
	2	On course	
	3	End parking instructs ack	
	4	Arrive at ramp threshold	05:06:30
	5		
	6		

1	Mission:	LAX to JFK
1.4	Period:	Land
1.4.4	Phase:	Taxi In
1.4.4.1	Segment:	Taxi to ramp

		Dependency				Performance	
		Event		Function			
	Function	Pro	Ret	Seq	Con	Schedule	Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
b	Request parking instructions					Descrete	Comm
c	Receive parking instructions			F1b		Descrete	Comm
d	Acknowledge instructions			F1c		Descrete	Comm
F2	Manage Aircraft Systems/Procedures						
a	Monitor Systems Status					Intermit	Inform
b	Access after landing checklist	E2				Descrete	Action
c	Retract flaps/slats			F2b		Descrete	Action
d	Disarm spoilers			F2b		Descrete	Action
e	Deactivate navigation lights			F2b		Descrete	Action
f	Deactivate anti-collision lights			F2b		Descrete	Action
g	Deactivate hi int recog lights			F2b		Descrete	Action
h	Deactivate main landing lights			F2b		Descrete	Action
i	Activate ground flood lights			F2b		Descrete	Action
j	Deactivate anti ice system as reqd			F2b		Descrete	Action
k	Deactivate ignition system			F2b		Descrete	Action
l	Deactivate weather radar as reqd			F2b		Descrete	Action
m	Stow after landing checklist		E4			Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Maintain Taxi Speed				F3cd	Continu	
	1 Monitor Indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 Modify thrust commands as required					Intermit	Action
c	Alter heading 90 degrees right	E1			F3b	Continu	
	1 Select steering option					Descrete	Decision
	2 Command right turn					Descrete	Action
	3 Monitor indicated/commanded position					Intermit	Inform
	4 Evaluate turn progress					Intermit	Decision
	5 Modify steering commands as required					Intermit	Action
d	Maintain heading (arrival gate)	E2		F3c	F3b	Continu	
	1 Monitor indicated/commanded heading					Intermit	Inform
	2 Evaluate heading change requirements					Intermit	Decision
	3 Modify steering commands as required					Intermit	Action
F4	Manage Flight Plan						
F5	Manage Contingencies						

ANALYSIS FORMAT

▽	Event
< >	Time Window
■	Time Duration

	Event	Time
E 1	Arrive at ramp threshold	05:06:30
2	Attain gate engagement spd	
3	Deceleration cue	
4	Aircraft stopped	05:07:30
5		
6		

1	Mission:	LAX to JFK
1.4	Period:	Land
1.4.4	Phase:	Taxi In
1.4.4.2	Segment:	Gate Engagement

		Dependency				Performance	
		Event		Function			
	Function	Pro	Ret	Seq	Con	Schedule	Category
F1	Manage Flight Coordination						
a	Monitor Partyline					Intermit	Inform
F2	Manage Aircraft Systems/Procedures						
a	Monitor Systems Status					Intermit	Inform
b	Engage ground maneuvering brake sys	E3			F3e	Descrete	Action
F3	Manage Aircraft Movement						
a	Monitor Ground/Flight Path					Intermit	Inform
b	Steer toward gate	E1			F3cde	Continu	
	1 Select steering option(nsewhl/ruddr)					Descrete	Decision
	2 Command steering directn/magnitude					Descrete	Action
	3 Monitor indicated/commanded position					Intermit	Inform
	4 Evaluate movement progress					Intermit	Decision
	5 Modify steering commands as required					Intermit	Action
c	Decelerate to gate engagement speed	E1			F3b	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command forward thrust decrease					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
d	Maintain gate engagement speed	E2		F3c	F3b	Continu	
	1 Monitor Indicated/commanded speed					Intermit	Inform
	2 Evaluate speed change requirements					Intermit	Decision
	3 *Modify thrust commands as required*					*Intermit*	*Action*
e	Decelerate to a stop	E3	E4	F3d	F2b,3b	Continu	
	1 Select speed decrease target					Descrete	Decision
	2 Command idle forward thrust					Descrete	Action
	3 Monitor indicated/commanded speed					Intermit	Inform
	4 Evaluate speed decrease progress					Intermit	Decision
	5 Modify thrust commands as required					Intermit	Action
F4	Manage Flight Plan						
F5	Manage Contingencies						

APPENDIX H

IDEF$_\emptyset$ MODEL OF ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS

CONCEPTUAL MODEL

The IDEF$_\emptyset$ model is a top-down analysis and it starts by representing the complete commercial transport flight activity as a simple unit—a box with arrow interfaces to activities outside of the unit. Since the single box represents the activity as a whole, the descriptive name written in the box is general. The same is true of the interface arrows since they represent the complete set of external interfaces to the whole activity.

The top-level box (Node A-0) that represents the activity as a single module is then decomposed (broken down into subfunctions/subactivities) on the following diagram. The decomposed diagram contains boxes that are major subfunctions/subactivities of the single parent module. Each of the subfunctions may be similarly decomposed to expose even more detail. Decomposition reveals a complete set of subfunctions, each represented as a box showing boundaries as defined by the interface arrows.

Each diagram in the IDEF$_\emptyset$ model is shown in precise relationship to the other diagrams by means of interconnecting arrows. When a module is decomposed into subfunctions, the interface between the subfunctions are shown as arrows. The name of each subfunction box, plus its labeled interfaces, define a bounded context for that module.

In all cases, every subactivity is restricted to contain only those elements that lie within the scope of the parent module. Further, the module cannot omit any elements. Thus, as already indicated, the parent module, or box, and its interfaces provide a context—nothing may be added or removed from this precise boundary.

Model Characteristics

The IDEF$_\emptyset$ model exhibits used in this document are composed of text, diagram, and glossary pages, in that order. The first text page provides an overall description of the model's structure, followed by the two pages that give an overview of the model in the form of a Node Index. The reader of the IDEF$_\emptyset$ model will find a series of diagrams and glossary pages that are arranged in sequence to develop the analysis process to the "Perform Takeoff" function.
IDEF$_\emptyset$ has its greatest strength in its effectiveness as a tool for dealing with complexity, because it starts with every general level of detail and gradually introduces more detail as the analysis proceeds to lower levels of analysis.

The IDEF$_\emptyset$ methodology does not address time or sequence, so it fails to meet all of the basic requirements for a function analysis. It must be supplemented by the use of additional techniques that define the required time/sequence flow so that a valid time line of activity can be established. Glossaries are provided for each applicable diagram so that the reader of the IDEF$_\emptyset$ model has sufficient understanding of the interfaces between activities or the "things" produced by the activities.

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 10/4/90 REV:		WORKING	READER DATE	CONTEXT:
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Decomposition of A-0 into its major constituent activities yields the top diagram, A0.

In order to deal with the complexity of the process required to permit the commercial airliner to accomplish its operational mission, the required activities (functions) have been partitioned into four groups as shown in Boxes 1,2,3, and 4. on Node A0. Box 5 on Node A0 addresses the contingency management functions that can affect Boxes 2,3, and 4. This is evident by the feedback loop from this function to each of these Boxes.

Extensive decomposition of the functions from level A0 has been confined to those activities that lead to Node A23, PERFORM TAKEOFF.

The detailed decomposition of Box A23 was used to compare functions/functional categories that were developed through the use of a comparable "bottom-up" analytical methodology. Due to the extensive amount of effort required to produce a single diagram, the comparison was confined to one specfific segment, LIFTOFF. The preparation of the IDEFø model was to provide assurance that both the top-down and bottom-up methods achieved comparable results, from the perspective of identifying similar functions at the detail level.

Decomposition of each function node identifies the major lower-level functions that, theoretically, become the basic functional and informational requirements to be used to allocate functions in a commercial transport aircraft crew system.

The reader of the IDEFø model is reminded that the process does not address time or sequence of acitivity, but it does show how one activity may constrain others. An example of this is given in the following description:

The function in Box 2, PERFORM DEPARTURE-RELATED ACTIVITIES, produces an output (Aircraft In Climb To Cruise Altitude) that is a condition state of the aircraft. This output becomes a constraint on the following function, PERFORM ENROUTE CRUISE ACTIVITIES. This indicates that neither Box 3 or Box 4 can be completed without the output of Box 2 being produced.

For additional information on the IDEFø process, refer to References, Item 3.

NODE: FACT / T1	TITLE: TEXT: ACCOMPLISH COMMERCIAL FLIGHT MISSIONS	NUMBER: DG - 001

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 10/2/90 REV:		WORKING	READER	DATE	CONTEXT:
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				RECOMMENDED			
				PUBLICATION			

A-0 ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS
A0 ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS
- A1 PERFORM PRE-DEPARTURE ACTIVITIES
- A2 PERFORM DEPARTURE-RELATED ACTIVITIES
  - A21 ACCOMPLISH BEFORE TAXI ACTIVITIES
    - A211 ACCOMPLISH BEFORE START/PUSHBACK
    - A212 PERFORM ENGINE START
    - A213 PERFORM AFTER START ACTIVITIES
  - A22 PERFORM TAXI OUT
    - A221 PERFORM TAXI
    - A222 PERFORM BEFORE TAKEOFF ACTIVITIES
  - A23 PERFORM TAKEOFF
    - A231 COMMUNICATE DURING TAKEOFF
    - A232 CONTROL AIRCRAFT DURING TAKEOFF
      - A2321 CAPTURE AIRCRAFT FLIGHT DATA
      - A2322 CONTROL AIRCRAFT ATTITUDE
        - A23221 CONTROL AIRCRAFT PITCH ANGLE & RATE
        - A23222 CONTROL AIRCRAFT ROLL ANGLE & RATE
        - A23223 CONTROL AIRCRAFT YAW
      - A2323 CONTROL AIRCRAFT AIRSPEED
        - A23231 MONITOR/VERIFY AIRSPEED
        - A23232 SELECT AIRSPEED CHANGE OPTIONS
        - A23233 COMMAND AIRSPEED INCREASE
        - A23234 COMMAND AIRSPEED DECREASE
        - A23235 COMMAND THRUST, DRAG, ATTITUDE CHANGE

NODE: FACT / T2	TITLE: NODE INDEX: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG -002

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 10/2/90 REV:		WORKING	READER	DATE	CONTEXT:
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A2324 CONTROL AIRCRAFT CONFIGURATION
- A23241 MONITOR AIRCRAFT CONFIGURATION
- A23242 SELECT AIRCRAFT CONFIGURATION CHANGE OPTIONS
- A23243 COMMAND AIRCRAFT CONFIGURATION CHANGE
- A23244 VERIFY CONFIGURATION DURING TAKEOFF

A2325 CONTROL AIRCRAFT ALTITUDE
- A23251 MAINTAIN DESIRED AIRSPEED
- A23252 MAINTAIN DESIRED PITCH ANGLE & RATE
- A23253 PROVIDE AIRCRAFT LIFT CONTROL
- A23254 CONTROL AIRCRAFT VERTICAL VELOCITY

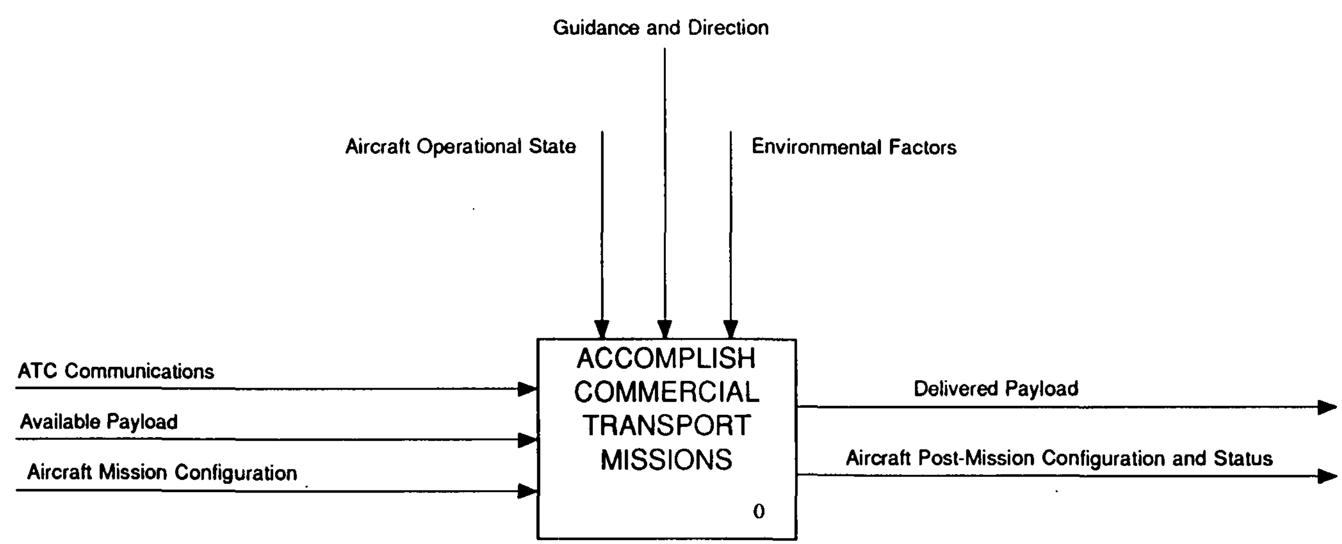
A2326 CONTROL AIRCRAFT HEADING
- A23261 MONITOR/VERIFY AIRCRAFT HEADING
- A23262 SELECT HEADING CHANGE OPTIONS
- A23263 COMMAND ROLL CHANGE CONTROL
- A23264 COMMAND YAW MODIFICATION

A233 MANAGE AIRCRAFT SYSTEMS

A3 PERFORM ENROUTE/CRUISE ACTIVITIES

NODE: FACT / T3	TITLE: NODE INDEX: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG -003

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/13/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: NONE



PURPOSE:
To define the functional activities that relate to the performance of a commercial flight mission

VIEWPOINT:
Crew Systems Operations Specialist

NODE: FACT A-0	TITLE: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG-01

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/25/90 REV:		WORKING	READER DATE	CONTEXT:
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				PUBLICATION		

GLOSSARY - FACT A-0:

AIRCRAFT OPERATIONAL STATE - The aircraft's operational status. Includes the configuration, operational capabilities, and technologies that are available in the baseline aircraft.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions.

GUIDANCE AND DIRECTION - Guidance and direction provided through the use of FARs, Advisory Circulars, NOTAMs, the various airline company regulations and requirements, and information provided by the ATC Controller. Includes Air Route Traffic Control Centers (ARTCC), available Navaids, operational sequences, the designated mission flight plan, and local operating procedures.

ATC COMMUNICATIONS - Communications received, or transmitted via the ARTCC network.

AVAILABLE PAYLOAD - Passengers and cargo available for loading, transporting, and unloading/disembarking at the destination.

AIRCRAFT MISSION CONFIGURATION, STATUS - The mission condition of the baseline aircraft. Includes the fuel state, physical location, systems capabilities, and general functional status of the aircraft.

NODE: FACT/ A-0	TITLE: GLOSSARY: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DGT-01

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/25/90 REV:		WORKING	READER DATE	CONTEXT:
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				PUBLICATION		

GLOSSARY - A-0 (CONT'D):

AIRCRAFT POST-MISSION POSITION, CONFIGURATION, AND STATUS - The post-mission condition of the baseline aircraft. Includes the fuel state, physical location, systems capabilities, and general functional status of the aircraft afte the mission has been completed.

DELIVERED PAYLOAD - Passengers and cargo unloaded at their final destination.

ATC CONTROLLER - Communications through the ARTCC network is handled primarily by the Controller that functions as an advisor/director of air traffic, route clearance, and enroute navigation support to the flight crew. ATC Controller's interface with the flight crew during the departure, enroute, and arrival phases of the mission.

NODE: FACT A-0 (CONT'D)	TITLE: GLOSSARY: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DGT- 02

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/13/90 REV:		WORKING	READER	DATE	CONTEXT: TOP
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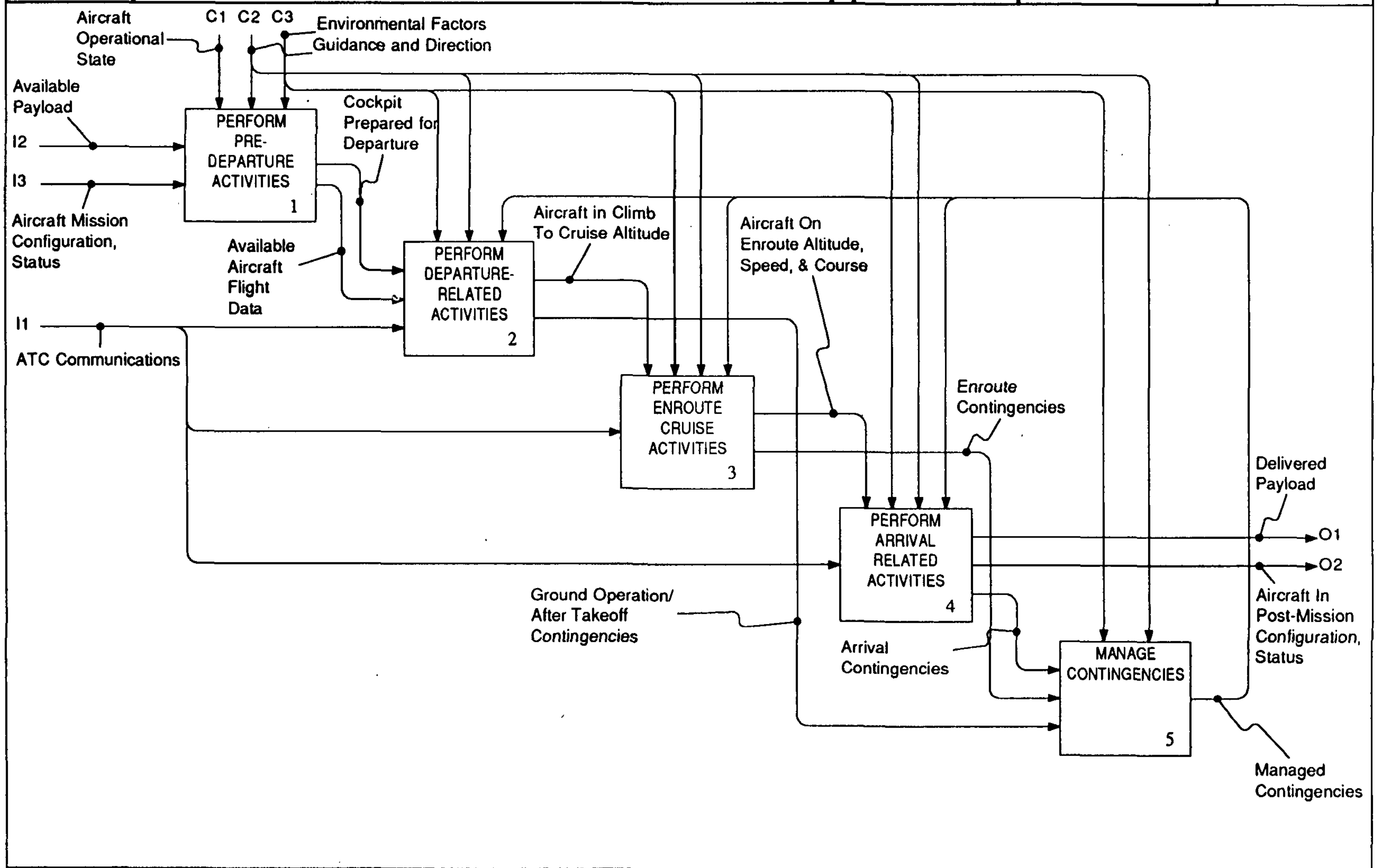

NODE: FACT A0	TITLE: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DG- 02

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/25/90 REV:		WORKING	READER DATE	CONTEXT:
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				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A0:

AIRCRAFT OPERATIONAL STATE - The aircraft's operational status. Includes the configuration, operational capabilities, and technologies that are available in the baseline aircraft.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions.

GUIDANCE AND DIRECTION - Guidance and direction provided through the use of FARs, Advisory Circulars, NOTAMs, the various airline company regulations and requirements, and information provided by the ATC controller. Includes Air Route Traffic Control Centers (ARTCC), available Navaids, operational sequences, the designated mission flight plan, and local operating procedures.

ATC COMMUNICATIONS - Communications received, or transmitted via the ARTCC network.

AVAILABLE PAYLOAD - Passengers and cargo available for loading, transporting, and unloading/disembarking at destination.

CREW REPORTS - *Communications that originate from either flight or ground crew members. Crew reports are* usually initiated as a result of guidance given in the Flight Manual or local operating procedures.

AIRCRAFT MISSION POSITION, CONFIGURATION, AND STATUS - The mission condition of the baseline aircraft prior to performing the pre-departure activities. Includes the fuel state, physical location, systems capabilities, and general functional status of the aircraft.

COCKPIT PREPARED FOR DEPARTURE - The cockpit is prepared for departure after the final cockpit operational sequences have been completed.

NODE: FACT/ A0	TITLE: GLOSSARY: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DGT-03

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/25/90 REV:		WORKING	READER DATE	CONTEXT:
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				PUBLICATION		

GLOSSARY - FACT A0 (CONT'D):

GROUND OPERATIONS/AFTER TAKEOFF CONTINGENCIES - These are the contingencies, or unexpected events, that occur during the pre-takeoff and after takeoff segments of the mission. Typically these may include failures of aircraft systems during initialization and activation. Electrical systems, hydraulic systems, and propulsion systems may be included in this category.

AIRCRAFT IN CLIMB TO CRUISE ALTITUDE - The state of the aircraft after the initial climb segment has been completed.

AIRCRAFT ON ENROUTE ALTITUDE, SPEED, AND COURSE - The state of the aircraft during the enroute cruise period. During this period and phase of the mission, the aircraft is level at the assigned altitude (FL) and the route to destination is being flown as planned.

AIRCRAFT POST-MISSION POSITION, CONFIGURATION, AND STATUS - The post-mission condition of the baseline aircraft. Includes the fuel state, physical location, systems capabilities, and general functional status of the aircraft after the mission has been completed.

MANAGED CONTINGENCIES - The status of the aircraft, crew, and payload subsequent to the actions taken in the "Manage Contingencies" function.

AVAILABLE AIRCRAFT FLIGHT DATA - Aircraft flight data that is generated within the aircraft. Flight data includes attitude, altitude, velocity, heading, flight configuration,etc.

NODE: FACT A0 (CONT'D)	TITLE: GLOSSARY: ACCOMPLISH COMMERCIAL TRANSPORT MISSIONS	NUMBER: DGT-04

USED AT:

AUTHOR: R. T. Goins
PROJECT: FACT

DATE: 9/15/90
REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

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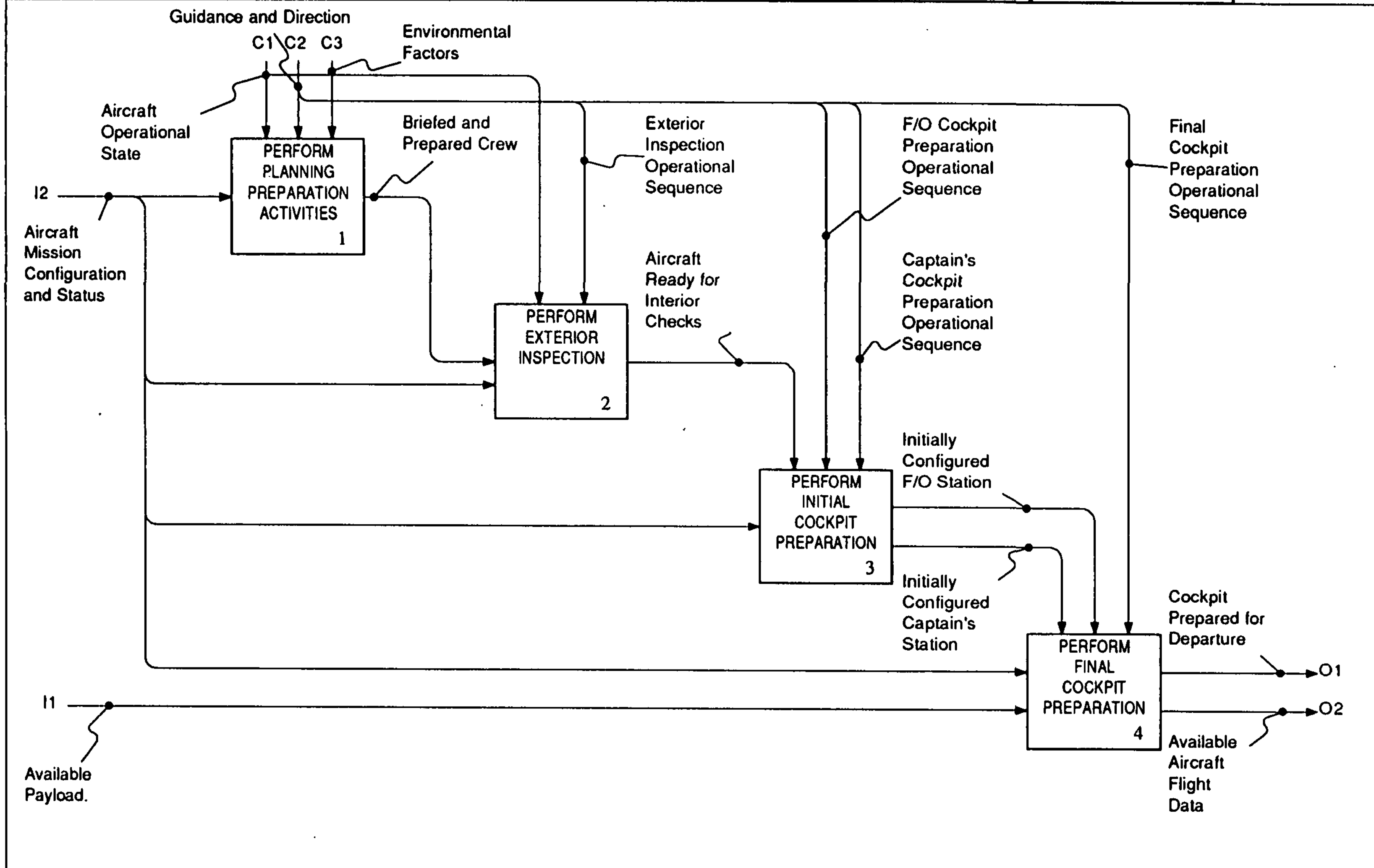
	RECOMMENDED
	PUBLICATION

READER DATE

CONTEXT:DG-02

A0



NODE: FACT A1

TITLE: PERFORM PRE- DEPARTURE ACTIVITIES

NUMBER: DG- 03

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
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				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A1:

AVAILABLE PAYLOAD - Passengers and cargo available for loading, transporting, and unloading/disembarking at destination.

AIRCRAFT MISSION POSITION, CONFIGURATION, AND STATUS - The mission condition of the baseline aircraft. Includes the fuel state, physical location, systems capabilities, and general functional status of the aircraft.

AIRCRAFT OPERATIONAL STATE - The aircraft's operational status. Includes the configuration, operational capabilities, and technologies that are available in the baseline aircraft.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions.

GUIDANCE AND DIRECTION - Guidance and direction provided through the use of FARs, Advisory Circulars, NOTAMs, the various airline company regulations and requirements, and information provided by the ATC controller. Includes Air Route Traffic Control Centers (ARTCC), available Navaids, operational sequences, the designated mission flight plan, and local operating procedures.

BRIEFED AND PREPARED CREW - This condition must exist before the crew can begin their duties of pre-flight of the aircraft. The flight crew reviews the mission flight plan, receives the weather briefing, and determines the status of the aircraft during the planning and preparation activity that precedes this condition.

NODE: FACT / A1	TITLE: GLOSSARY: PERFORM PRE-DEPARTURE ACTIVITIES	NUMBER: DGT-05

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
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				RECOMMENDED		
				PUBLICATION		

GLOSSARY - A1 (CONT'D):

AIRCRAFT READY FOR INTERIOR CHECKS - The aircraft "walk-around" must be complete before this condition may be met. The exterior of the aircraft is inspected as detailed in the prescribed operational sequence.

INITIALLY CONFIGURED FIRST OFFICER (F/O) STATION - This condition exists after the First Officer completes his/her F/O Cockpit Preparation operational sequence. The Final Cockpit operational sequence follows when both pilots are present.

COCKPIT PREPARED FOR DEPARTURE - This condition exists after the Captain and The First Officer completes the Final Cockpit Preparation operational sequence.

NODE: FACT / A1 (CONT'D)	TITLE: GLOSSARY: PERFORM PRE-DEPARTURE ACTIVTIES	NUMBER: DGT- 06

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:		WORKING	READER	DATE	CONTEXT: DG-02
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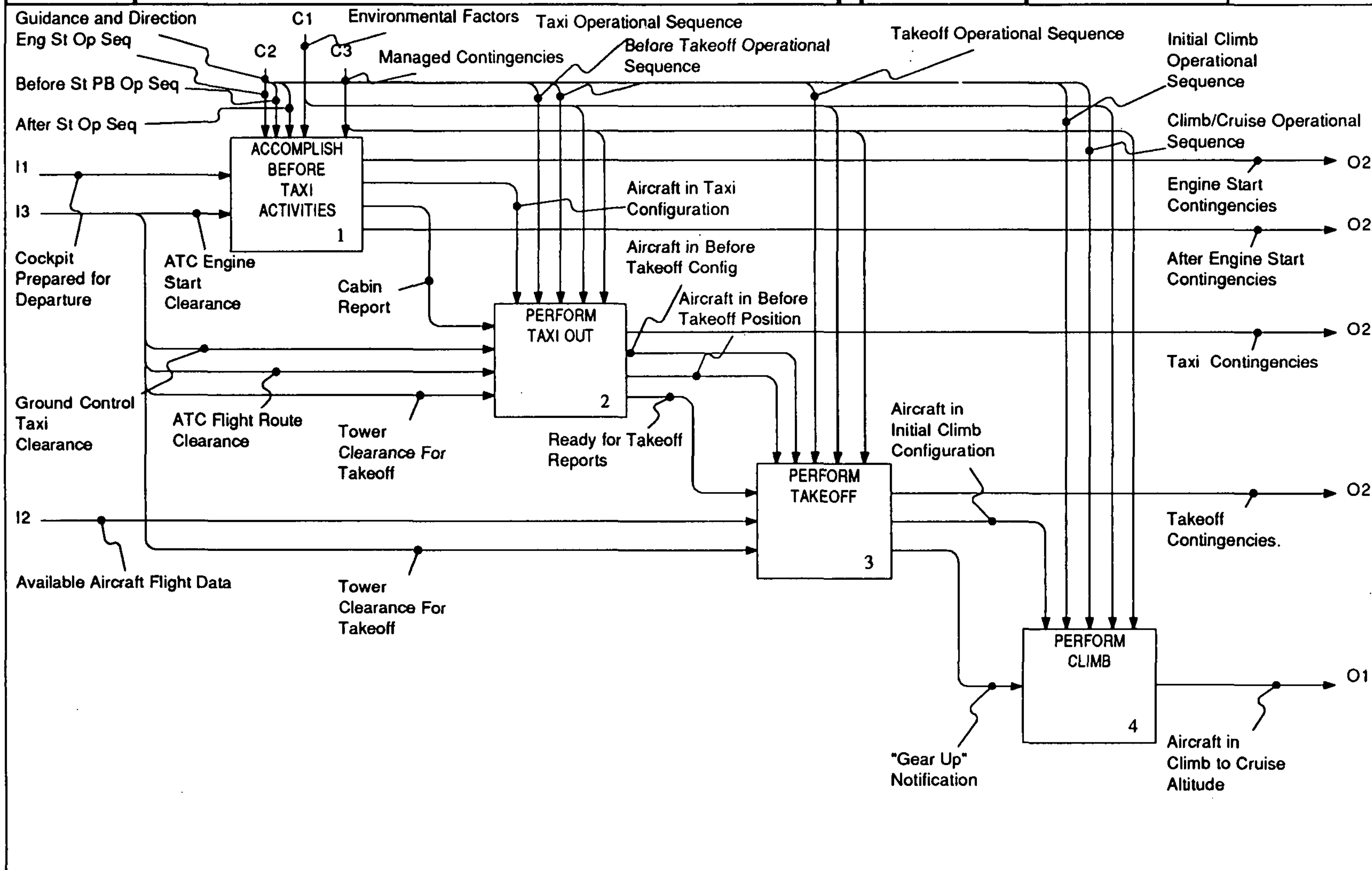
				RECOMMENDED			
				PUBLICATION			A0



NODE: FACT A2	TITLE: PERFORM DEPARTURE- RELATED ACTIVITIES	NUMBER: DG- 04

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
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				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A2:

COCKPIT PREPARED FOR DEPARTURE - This condition exists after the Captain and The First Officer completes the Final Cockpit Preparation operational sequence.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions, etc.

MANAGED CONTINGENCIES - The status of the aircraft, crew and payload subsequent to the actions taken in the "Manage Contingencies" function.

ENGINE START OPERATIONAL SEQUENCE - The operational sequence of events required to start the aircraft engines.

BEFORE START/PUSHBACK OPERATIONAL SEQUENCE - The operational sequence of events after the aircraft engines are started and the aircraft is pushed back from the loading gate/parking location.

AFTER START OPERATIONAL SEQUENCE - The operational sequence of events before the aircraft engines are started.

TAXI OPERATIONAL SEQUENCE - The operational sequence of events required to taxi the aircraft.

BEFORE TAKEOFF OPERATIONAL SEQUENCE - The operational sequence of events accomplished before aircraft takeoff.

TAKEOFF OPERATIONAL SEQUENCE - The operational sequence of events accomplished during the takeoff segment.

NODE: FACT / A2	TITLE: GLOSSARY: PERFORM DEPARTURE-RELATED ACTIVITIES	NUMBER: DGT- 07

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A2 (CONT'D):

INITIAL CLIMB OPERATIONAL SEQUENCE - The operational sequence of events accomplished during the initial climb after takeoff.

ATC ENGINE START CLEARANCE - Clearance provided by the Air Traffic Controller that gives permission to start the aircraft engines.

AIRCRAFT IN TAXI CONFIGURATION - This is an aircraft condition state. The aircraft engines are started, the aircraft systems are activated, and the necessary operational sequence of events have been accomplished that place the aircraft in a taxi configuration.

GROUND CONTROL TAXI CLEARANCE - Clearance provided by the ATC Ground Controller that gives permission to taxi the aircraft to the active runway.

CABIN REPORT - This is the report that comes from the cabin crew that acknowledges the flight deck's request to report their preparedness for takeoff.

AIRCRAFT IN BEFORE TAKEOFF CONFIGURATION - This is an aircraft condition state. The aircraft engines are started, the systems are activated, and the necessary operational sequence of events have been accomplished that place the aircraft in a before takeoff configuration.

NODE: FACT / A2 (CONT'D)	TITLE: GLOSSARY: PERFORM DEPARTURE-RELATED ACTIVITIES	NUMBER: DGT-08

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A2 (CONT'D):

AIRCRAFT IN BEFORE TAKEOFF POSITION - This is an aircraft condition state. The aircraft engines are started, the systems are activated, the aircraft has taxiied to the active runway, and the necessary operational sequence of events have been accomplished that place the aircraft in a before takeoff position.

ATC FLIGHT ROUTE CLEARANCE - Clearance provided by the Air Traffic Controller that gives permission to fly the route as requested. Amendments to the requested route may be included in this transmission.

TOWER TAKEOFF CLEARANCE - Clearance provided by the airport control tower that permits the aircraft to take the active runway and complete the takeoff. This clearance is given only after the tower has checked the active runway for arriving or departing air traffic and cleared the entry into the active runway visually.

READY FOR TAKEOFF REPORTS - These are the reports that occur within the aircraft. Each report confirms that the affected crew is prepared for takeoff.

AIRCRAFT IN INITIAL CLIMB CONFIGURATION - This is an aircraft condition state. The aircraft has lifted off the runway. The gear, flaps/slats have been retracted, and the aircraft is on initial climb speed schedule enroute to the initial departure fix.

AVAILABLE AIRCRAFT FLIGHT DATA - This is the flight data that is generated from within the aircraft. It includes the data that represents the attitude, altitude, velocity, heading, and configuration of the aircraft.

"GEAR UP" NOTIFICATION - This notifies the crew that the aircraft has met the conditions required to retract the landing gear.

NODE: FACT / A2 (CONT'D)	TITLE: GLOSSARY: PERFORM DEPARTURE-RELATED ACTIVITIES	NUMBER: DGT- 09

GLOSSARY - FACT A2 (CONT'D):

AIRCRAFT IN CLIMB TO CRUISE ALTITUDE - This is an aircraft condition state. The aircraft has completed the initial climb segment of the mission, and is continuing enroute climbing to the initial level-off altitude.

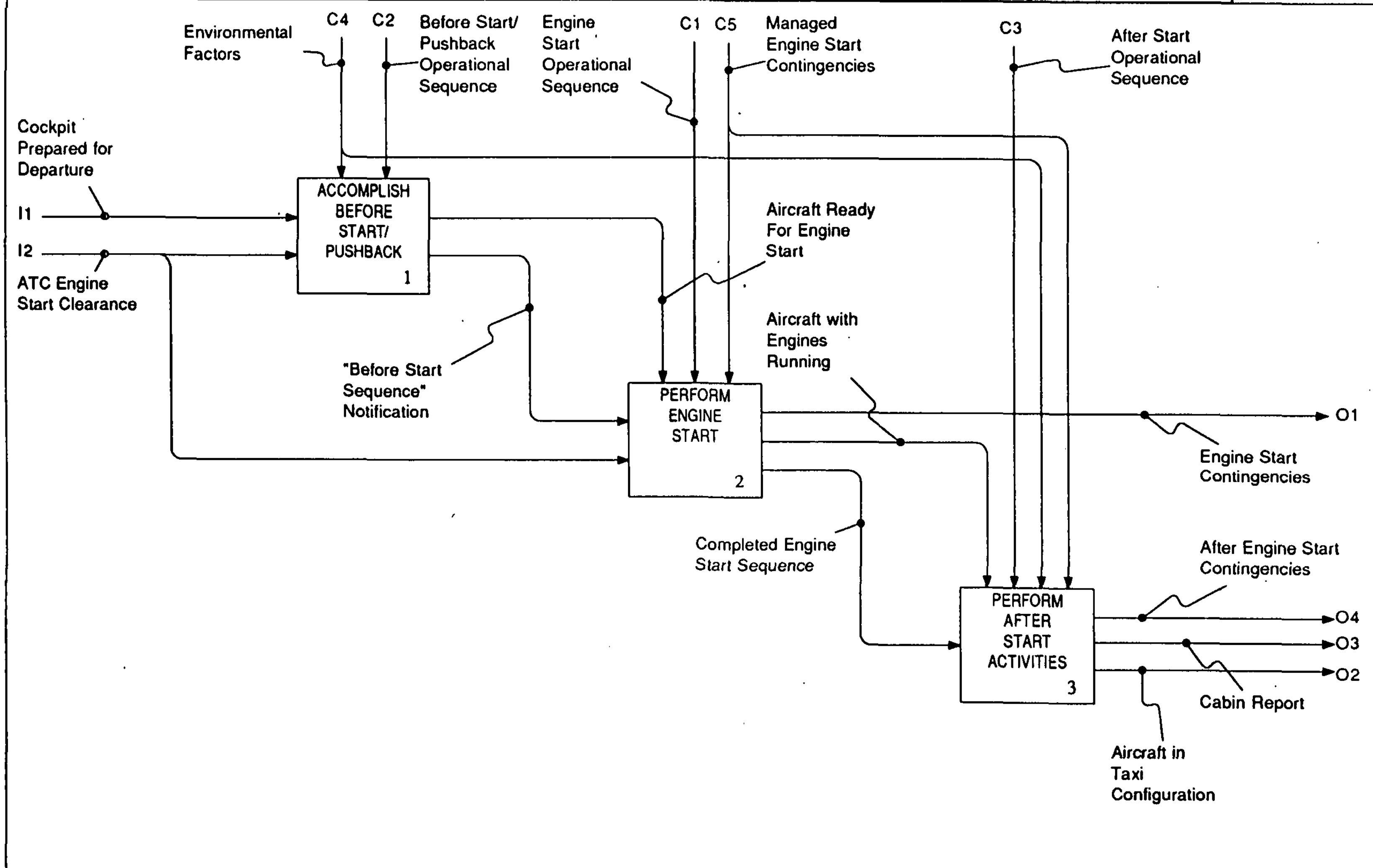
ENGINE START CONTINGENCIES - These are the unexpected events that occur during
û® sequence of starting the aircraft engines. Typical engine start contingencies may be: hot start (high EGT), hung start (low RPM), engine fire, etc.

AFTER ENGINE START CONTINGENCIES - These are the unexpected events that occur after the aircraft engines are started. Typical after engine start contingencies may be: low oil pressure, generator malfunctions, low cooling air flow,etc.

TAXI CONTINGENCIES - These are the unexpected events that occur during aircraft taxi. Typical taxi contingencies may be: steering/braking malfunctions, anti-ice malfunctions, etc.

TAKEOFF CONTINGENCIES - These are the unexpected events that occur during the aircraft takeoff segment of the mission. Typical takeoff contingencies may be: engine failure, asymmetrical flap/slat retraction,etc.

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-04 A2



NODE: FACT A21	TITLE: ACCOMPLISH BEFORE TAXI ACTIVITIES	NUMBER: DG- 05

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A21:

MANAGED ENGINE START CONTINGENCIES - The status of the aircraft, crew and payload during engine start and subsequent to the actions taken in the "Manage Contingencies" function.

"BEFORE START SEQUENCE" NOTIFICATION - This is a notification provided to the flight deck crew that the "before start" operational sequence is complete.

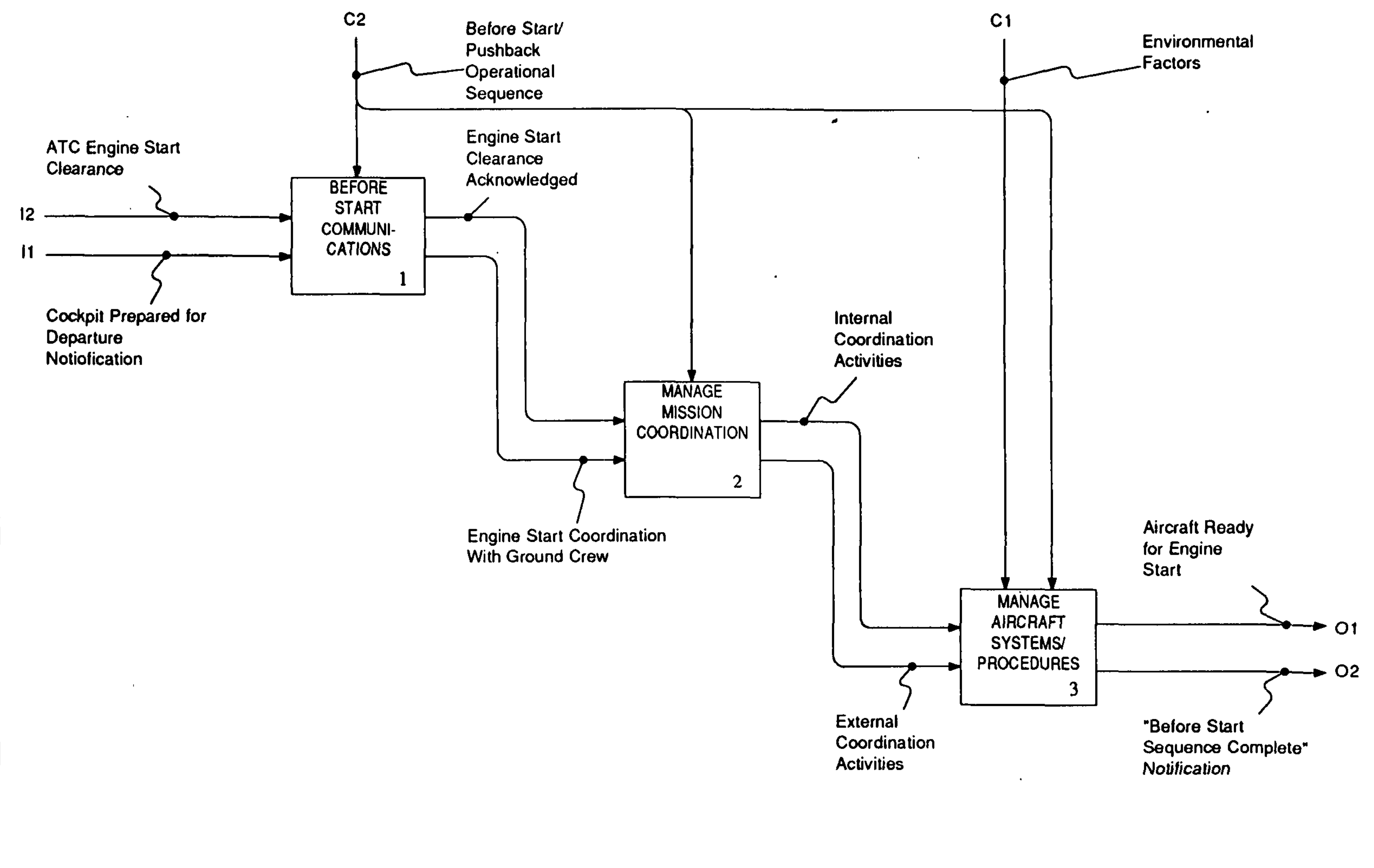
AIRCRAFT READY FOR ENGINE START - This is an aircraft condition state. The aircraft has been placed in a configuration that permits starting of the aircraft engines.

AIRCRAFT WITH ENGINES RUNNING - This is an aircraft condition state. The aircraft engines are now running after successful engine start on all engines.

COMPLETED ENGINE START SEQUENCE - This identifies the state of the operational sequence of events. Here the operational sequence is at the point where the engine start is complete.

NODE: FACT / A21	TITLE: GLOSSARY: ACCOMPLISH BEFORE TAXI ACTIVITIES	NUMBER: DGT-11

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:		WORKING	READER	DATE	CONTEXT: DG-05
			X	DRAFT			
			.	RECOMMENDED			
				PUBLICATION			A21



NODE: FACT A211	TITLE: ACCOMPLISH BEFORE START/ PUSHBACK	NUMBER: DG- 06

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A211:

ENGINE START CLEARANCE ACKNOWLEDGED - The clearance to start the aircraft engines, as it is received from the ATC Controller, is acknowledged.

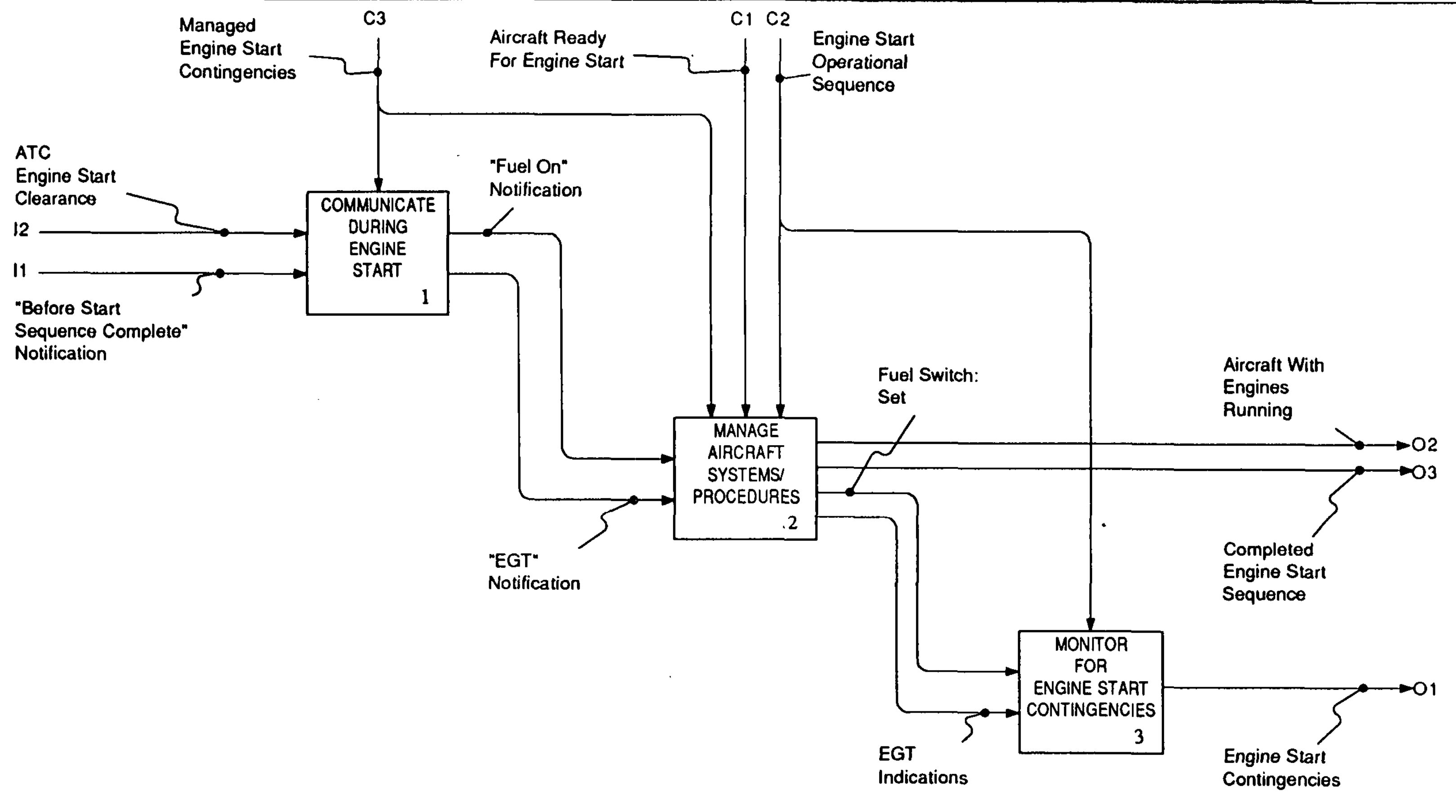
ENGINE START COORDINATION WITH GROUND CREW - The sequence of starting the aircraft engines is coordinated with the ground crew. This is accomplished so that the ground crew may be prepared for any abnormal situation that may occur during engine start. Also the coordination allows for the safety of the ground crew during the starting engines sequence.

INTERNAL COORDINATION ACTIVITIES - Activties coordinated within the aircraft cockpit and/or cabin.

EXTERNAL COORDINATION ACTIVITIES - Activities coordinated outside of the cockpit and/or cabin environments. This coordination includes those associated with either the ground crew or the ATC controlling functions.

NODE: FACT / A211	TITLE: GLOSSARY: ACCOMPLISH BEFORE START/PUSHBACK	NUMBER: DGT-12

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:		WORKING	READER	DATE	CONTEXT: DG-05 A21
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			



NODE: FACT A212	TITLE: PERFORM ENGINE START	NUMBER: DG- 07

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A212:

"FUEL ON" NOTIFICATION - This occurs after fuel flow indications are apparent.

"EGT" NOTIFICATION - This notification occurs after there is an apparent rise in the engine Exhaust Gas Temperature (EGT). EGT rise is a significant indication tha ignition has occurred.

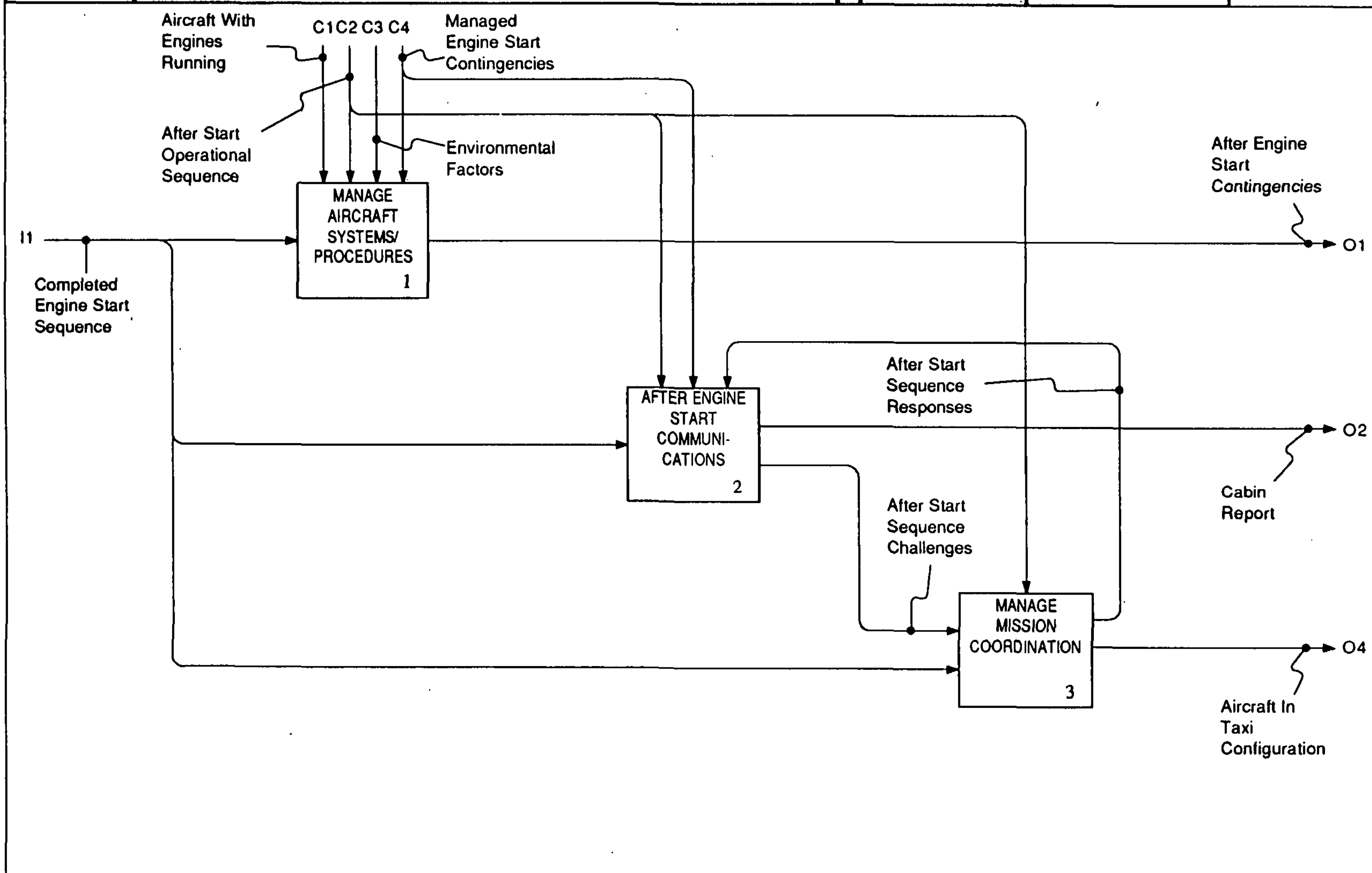
FUEL SWITCH: SET - This is a critical part of the operational sequence. Fuel pumping and distribution switches are set to provide fuel and fuel pressure to the proper engine selections.

EGT INDICATIONS - Stabilized indications of EGT are now available.

NODE: FACT /A212	TITLE: GLOSSARY: PERFORM ENGINE START	NUMBER: DGT-13

USED AT: | AUTHOR: R. T. Goins | DATE: 9/15/90
PROJECT: FACT | REV:
NOTES: 1 2 3 4 5 6 7 8 9 10

		READER	DATE	CONTEXT: DG-05
	WORKING			
X	DRAFT			
	RECOMMENDED			
	PUBLICATION			A21



NODE: FACT A213 | TITLE: PERFORM AFTER START ACTIVITIES | NUMBER: DG- 08

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A213:

AFTER START CHALLENGES - These are communications that occur between the cockpit crew. Challenge-response communications verify that critical operational sequences have been completed as specified. The "challenge" initiates the communication.

AFTER START RESPONSES - These are communications that occur between the cockpit crew. Challenge-response communications verify that critical operational sequences have been completed as specified. The proper "response" terminates the communication.

NODE: FACT / A213	TITLE: GLOSSARY: PERFORM AFTER START ACTIVITIES	NUMBER: DGT-14

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:		WORKING	READER DATE	CONTEXT: DG-04
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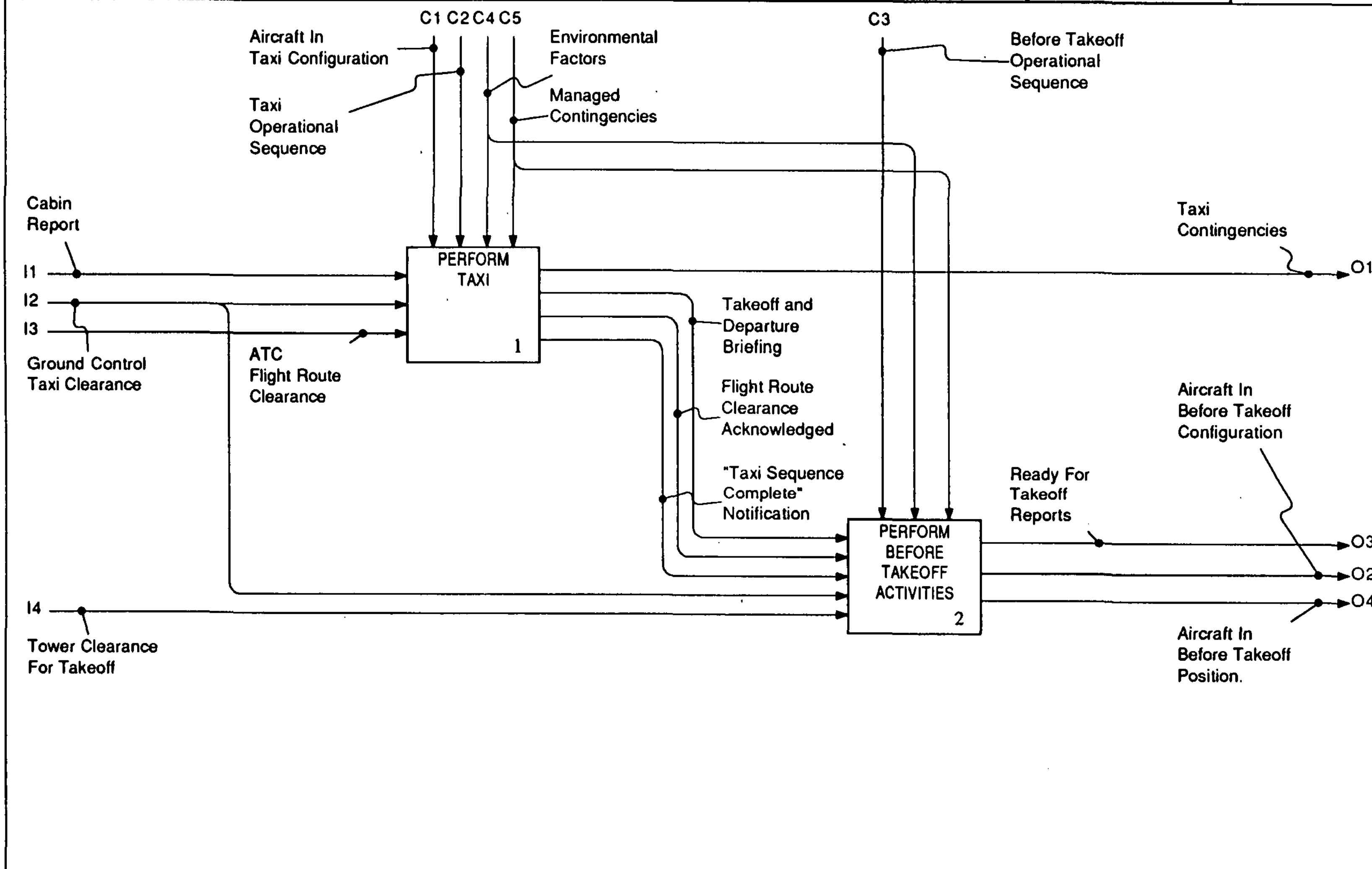
				RECOMMENDED		
				PUBLICATION		A2



NODE: FACT A22	TITLE: PERFORM TAXI OUT	NUMBER: DG- 09

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A22:

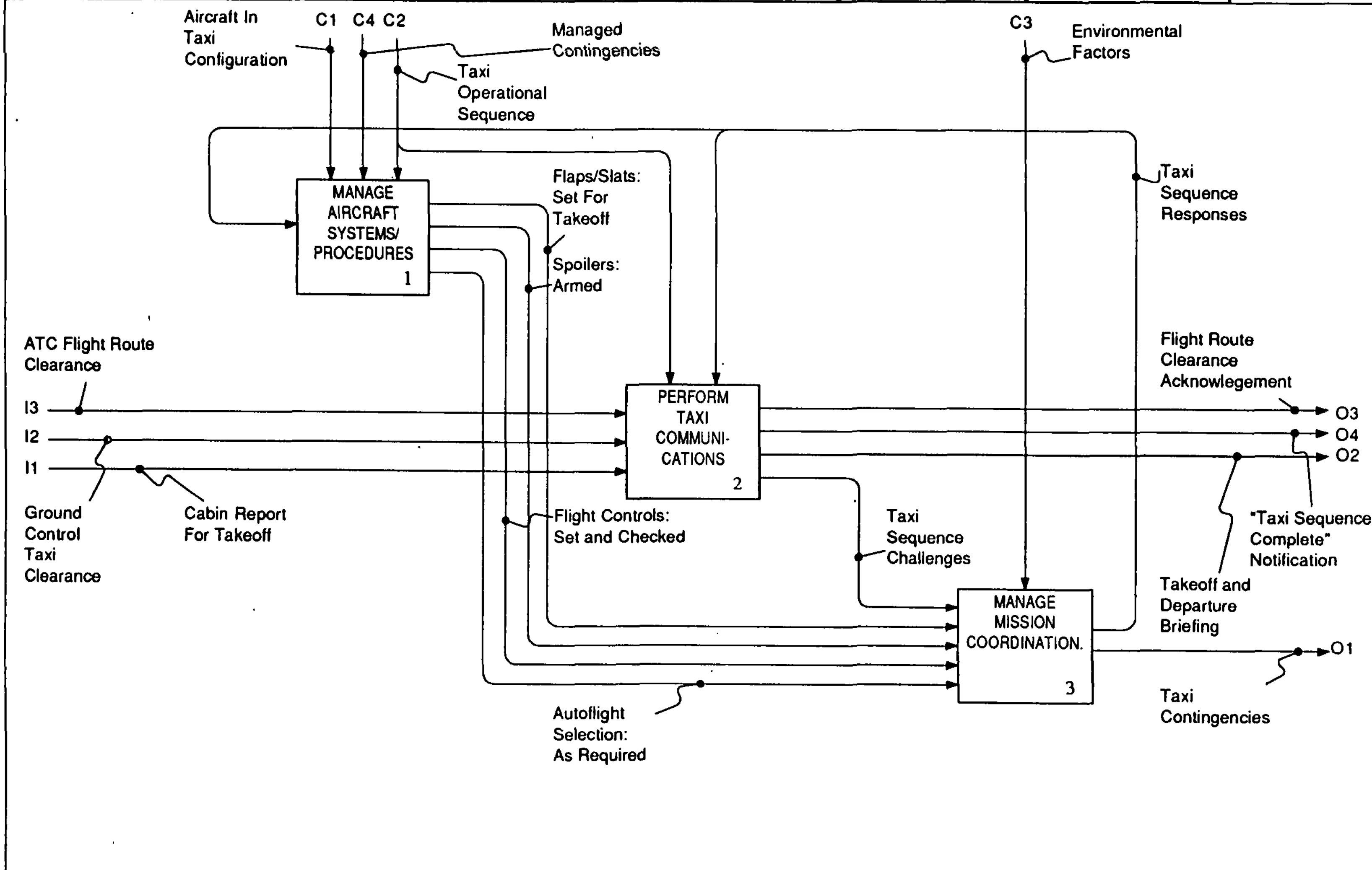
TAKEOFF AND DEPARTURE BRIEFING - This is a review and briefing of the critical activities that occur during the takeoff segment of the mission. The briefing is contained within the cockpit and/or cabin of the aircraft.

FLIGHT ROUTE CLEARANCE ACKNOWLEDGED - The flight deck crew acknowledges the receipt of the flight route clearance from the ATC Controller. Amendments to the original clearance are acknowledged at this time.

TAXI SEQUENCE NOTIFICATION - This notification occurs after the taxi operational sequences have been completed.

NODE: FACT / A22	TITLE: GLOSSARY: PERFORM TAXI OUT	NUMBER: DGT-15

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/15/90 REV:		WORKING	READER	DATE	CONTEXT: DG-09
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A22



NODE: FACT A221	TITLE: PERFORM TAXI	NUMBER: DG- 10

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A221:

FLAPS/SLATS: SET FOR TAKEOFF - High-lift devices (flaps and slats) are extended as required for takeoff.

SPOILERS: ARMED - Spoilers are configured for automatic extension if the throttles are retarded and the aircraft is not yet airborne. This selection allows for automatic airbraking during an aborted or rejected takeoff.

FLIGHT CONTROLS: SET AND CHECKED - The takeoff configuration of the flight controls are now verified by checking their selection and setting them as required.

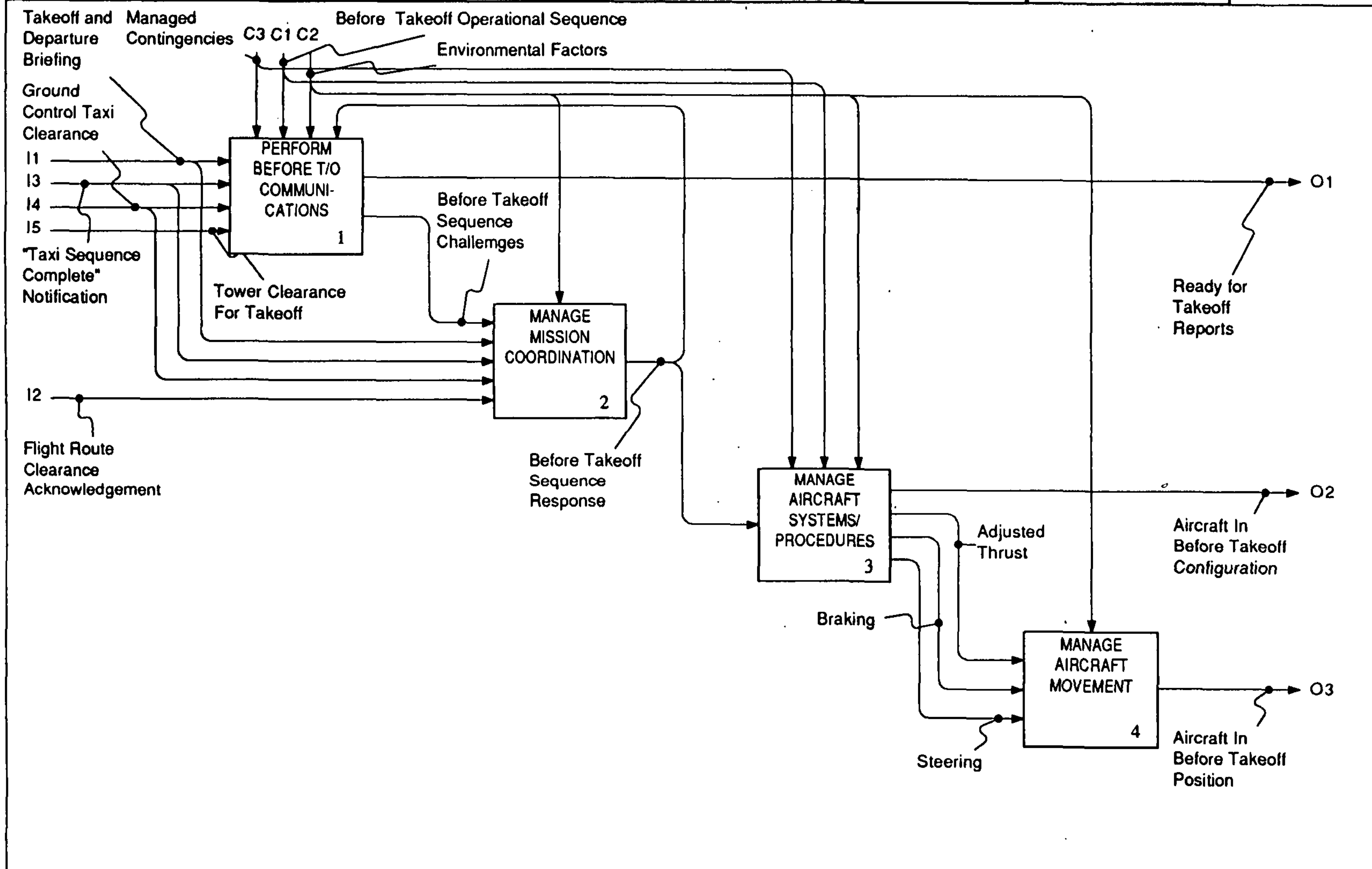
AUTOFLIGHT SELECTION: AS REQUIRED - Any "automatic flight" selections have now been made. The extent of the automatic flight selections available is dependent upon the unique configuration of the baseline aircraft.

TAXI SEQUENCE CHALLENGES - Specific critical operational sequences are verified by means of a challenge-response communication between the flight deck crew members. The "challenge" initiates the communication.

TAXI SEQUENCE RESPONSES - Specific critical operational sequences are verified by means of a challenge-response communication between the flight deck crew members. The "response" terminates the communication.

NODE: FACT / A221	TITLE: GLOSSARY: PERFORM TAXI	NUMBER: DGT-16

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/17/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-09 A22



NODE: FACT A222	TITLE: PERFORM BEFORE TAKEOFF ACTIVITIES	NUMBER: DG- 11

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A222:

BEFORE TAKEOFF SEQUENCE CHALLENGES - Specific critical operational sequences are verified by means of a challenge-response communication between the flight deck crew members before the aircraft takeoff. The "challenge" initiates the communication.

BEFORE TAKEOFF SEQUENCE RESPONSES - Specific critical operational sequences are verified by means of a challenge-response communication between the flight deck crew members before the aircraft takeoff. The "response" terminates the communication.

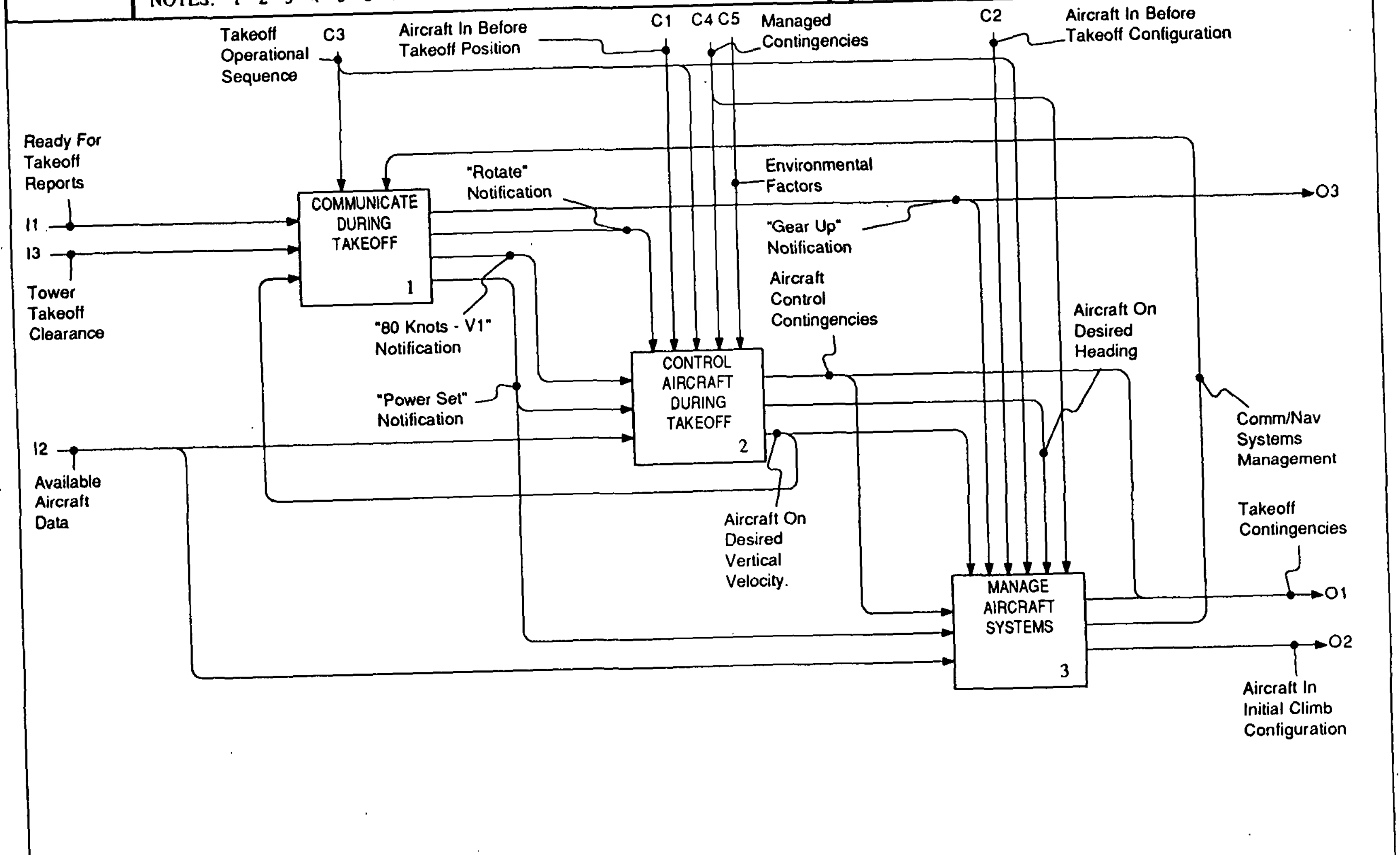
ADJUSTED THRUST - Adjustments made to the thrust settings to control the aircraft ground taxi speed.

BRAKING - Braking actions that are made to control the aircraft ground taxi speed.

STEERING - Steering actions that control the aircraft direction during the ground taxi sequence.

NODE: FACT / A222	TITLE: GLOSSARY: PERFORM BEFORE TAKEOFF ACTIVITIES	NUMBER: DGT-17

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/17/90 REV:		WORKING	READER	DATE	CONTEXT: DG-04
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2



NODE: FACT A23	TITLE: PERFORM TAKEOFF	NUMBER: DG- 12

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23:

"POWER SET" NOTIFICATION - This notifies the flight deck crew that the takeoff power setting has been accomplished.

"80 KNOTS - V1" NOTIFICATION - This notifies the flight deck crew that the first acceleration check point (80 KNOTS - V1) has occurred. This is a preparatory notification that the takeoff rotation point is approaching.

"ROTATION" NOTIFICATION - The point at which the aircraft pitch attitude is rotated to the takeoff attitude is notified to the flight deck crew. At this point the aircraft is rotated to the pre-determined takeoff rotation attitude at the specified rotation rate.

AIRCRAFT CONTROL CONTINGENCIES - Any unexpected aircraft control contingencies that occur during takeoff are included in this category.

AIRCRAFT ON DESIRED VERTICAL VELOCITY - After liftoff, the aircraft's ascent rate (vertical velocity) is controlled as required to attain a planned ascent rate, attain or maintain a desired altitude, or clear obstacles within the flight path.

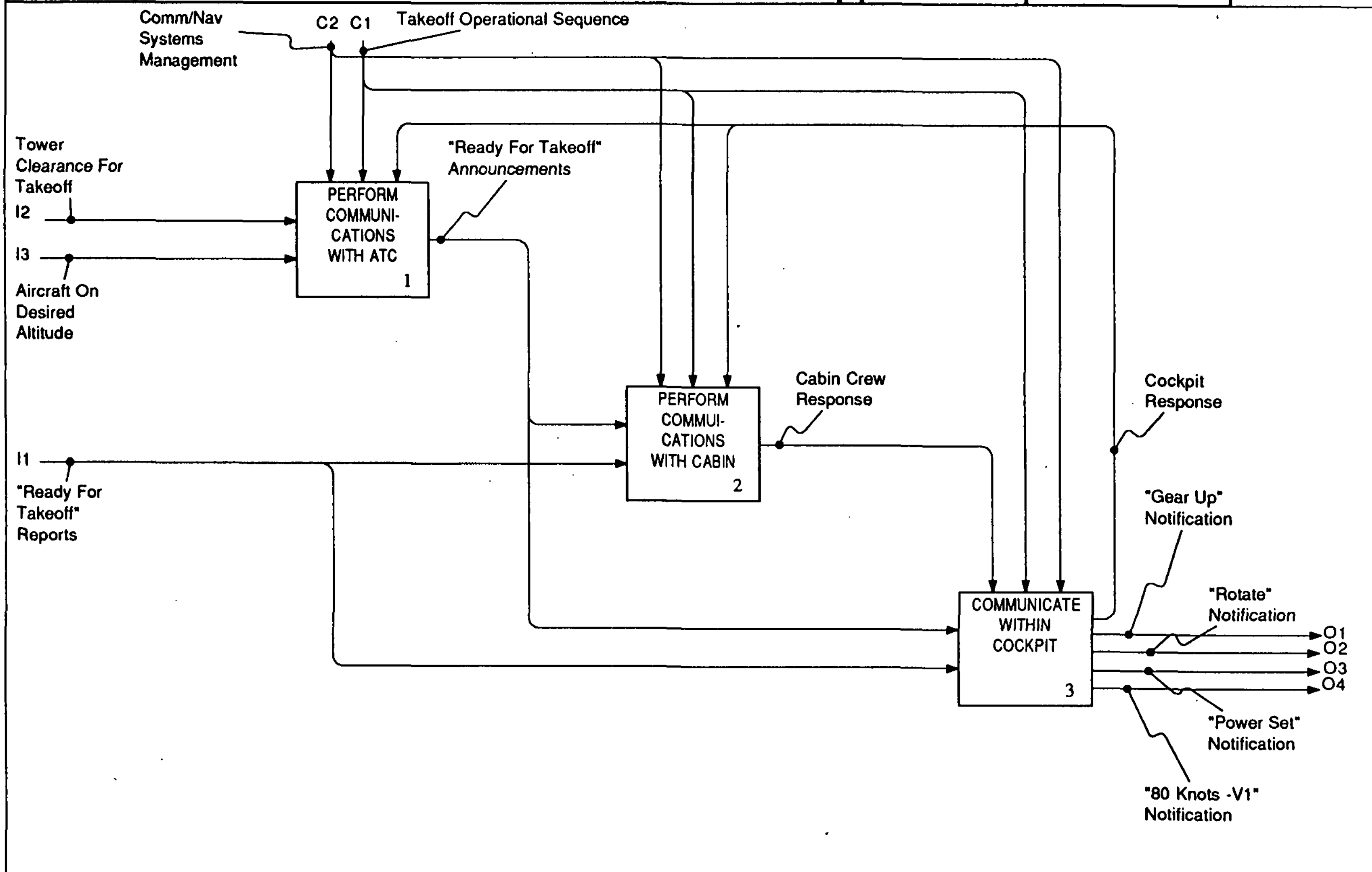
AIRCRAFT ON DESIRED HEADING - After liftoff, the aircraft's magnetic heading is controlled as required to either maintain the takeoff heading or acquire the heading to a specified initial departure fix.

NODE: FACT / A23	TITLE: GLOSSARY: PERFORM TAKEOFF	NUMBER: DGT-18

USED AT:

AUTHOR: R. T. Goins
PROJECT: FACT
DATE: 9/17/90
REV:
NOTES: 1 2 3 4 5 6 7 8 9 10

		READER	DATE	CONTEXT: DG-12
	WORKING			
X	DRAFT			
	RECOMMENDED			
	PUBLICATION			A23



NODE: FACT A231 | TITLE: COMMUNICATE DURING TAKEOFF | NUMBER: DG- 13

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A231:

COMM/NAV SYSTEMS MANAGEMENT - Management of the aircraft communications/navigation system as required to affect the necessary communications during the takeoff segment of the mission.

"READY FOR TAKEOFF" ANNOUNCEMENTS - This announcement advises the crew that the aircraft and crew are prepared for takeoff. Appropriate responses are required to ensure each crew compartment has received the announcement.

CABIN CREW RESPONSE - This is the cabin crew's response to the "ready for takeoff" announcement.

COCKPIT RESPONSE - This is the cockpit or flight deck crew's response to the "ready for takeoff" announcement.

NODE: FACT / A231	TITLE: GLOSSARY: COMMUNICATE DURING TAKEOFF	NUMBER: DGT-19

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/18/90 REV:		WORKING	READER	DATE	CONTEXT: DG-12
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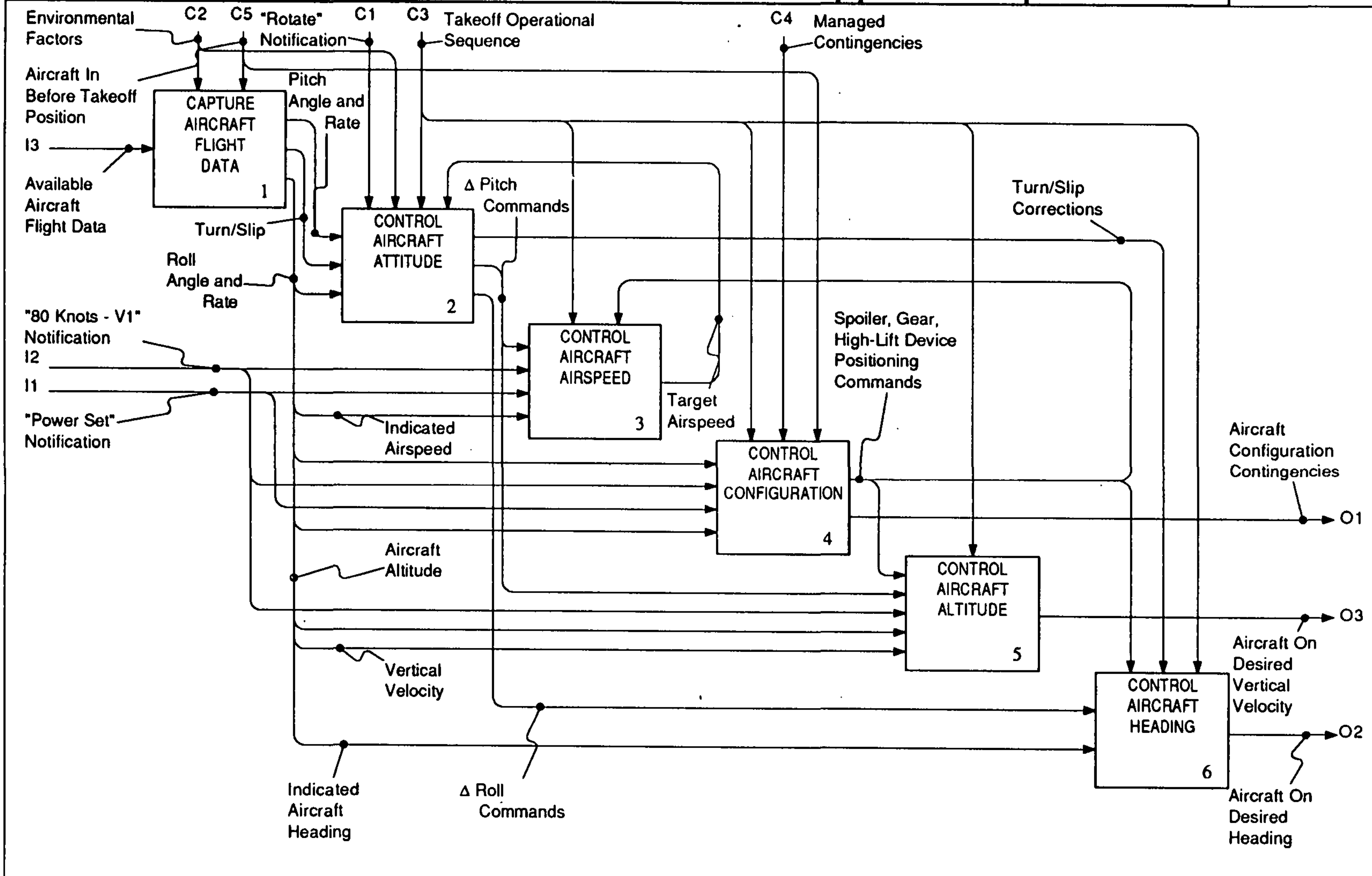
				RECOMMENDED			
				PUBLICATION			A23



NODE: FACT A232	TITLE: CONTROL AIRCRAFT DURING TAKEOFF	NUMBER: DG- 14

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A232:

PITCH ANGLE AND RATE - This is a measurement of the aircraft's pitch angle and rate of pitch angle change (Δ Pitch) during the takeoff segment of the mission. Pitch angle and pitch rate values are provided in degrees and degrees change per second, respectively.

TURN/SLIP - This is a measurement of the aircraft's yaw angle and rate of change of yaw angle (Δ Yaw) as it relates to the turning and rolling of the aircraft during the takeoff segment of the mission. Yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

ROLL ANGLE AND RATE - This is a measurement of the aircraft's roll angle and rate of roll angle change (Δ Roll) during the takeoff segment of the mission. Roll angle and roll rate values are provided in degrees and degrees change per second, respectively.

INDICATED AIRSPEED - This is a measurement of the aircraft's indicated airspeed during the takeoff segment of the mission. Indicated airspeed is obtained from the pitot-static data provided by the air data computational system. Indicated airspeed is provided in nautical miles per hour or "knots indicated airspeed" (KIAS).

AIRCRAFT ALTITUDE - This is a measurement of the aircraft's altitude during the takeoff segment of the mission. Aircraft altitude may be available from either a barometric source (pressure altimeter) or above-ground-level (AGL) source provided by the radar altimeter.

NODE: FACT / A232	TITLE: GLOSSARY: CONTROL AIRCRAFT DURING TAKEOFF	NUMBER: DGT-20

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 10/9/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A232 (CONT'D):

VERTICAL VELOCITY - This is a measurement of the aircraft's ascent or descent rate during the takeoff segment of the mission. Aircraft vertical velocity is provided in feet-per-minute (FPM) change. Aircraft vertical velocity may be determined from a variety of sources: change in barometric altitude per minute, change in absolute altitude per minute, or a discrete measurement of actual vertical acceleration using precision accelerometers.

INDICATED AIRCRAFT HEADING - This a measurement of the aircraft's magnetic heading during the takeoff segment of the mission. Aircraft magnetic heading is provided in degrees (0-359) and increments of degrees for precision navigational computations.

Δ PITCH COMMANDS - This is measurement of the change in pitch angle per second of time.

Δ ROLL COMMANDS - This is measurement of the change in roll angle per second of time.

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear, lift or drag devices.

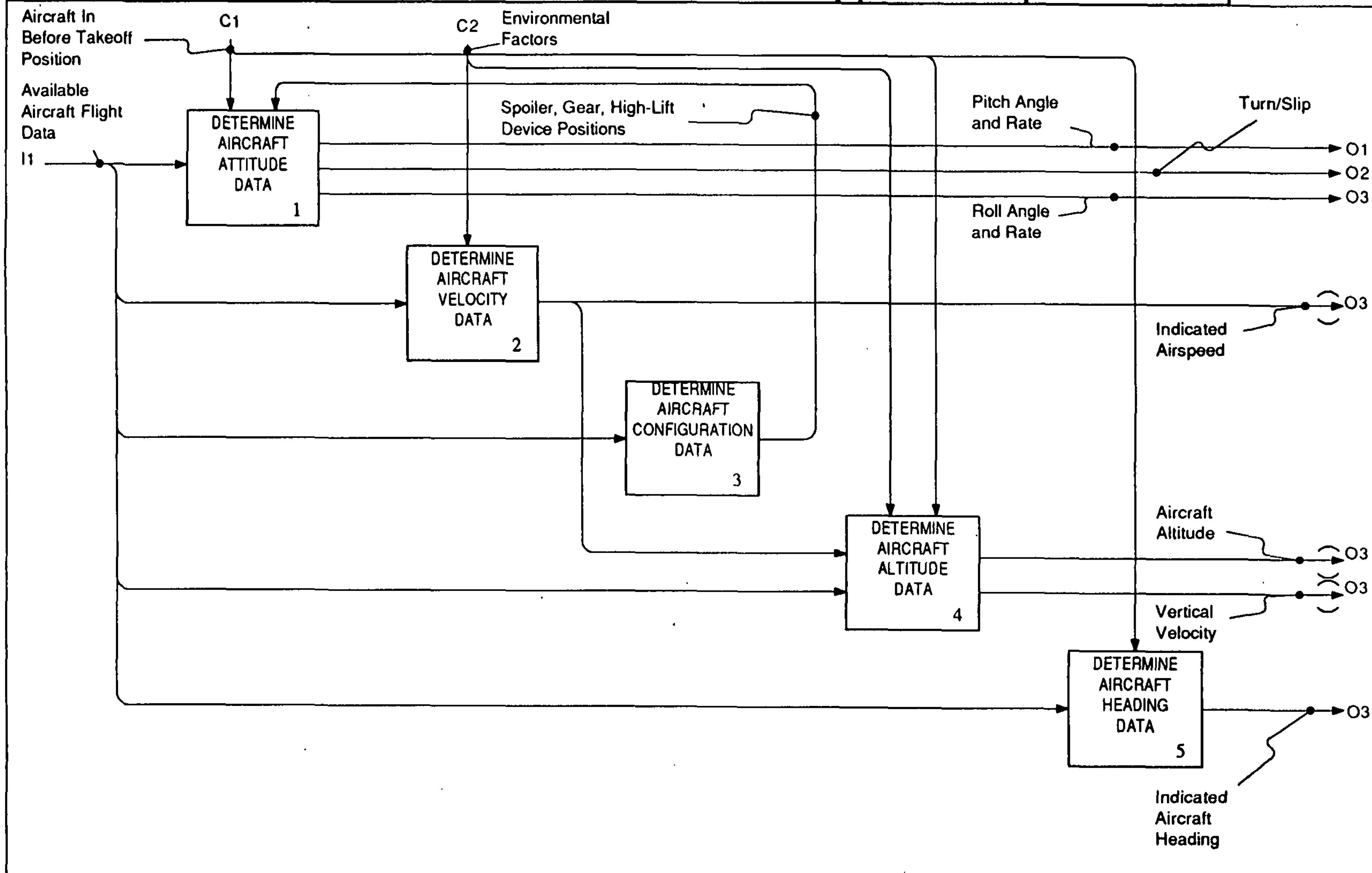
NODE: FACT / A232 (CONT'D)	TITLE: GLOSSARY: CONTROL AIRCRAFT DURING TAKEOFF	NUMBER: DGT-21

GLOSSARY - FACT A232 (CONT'D):

AIRCRAFT CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the flight control configuration of the aircraft. Contingencies in this category may be those related to the retraction or extension of the spoilers, landing gear, or the flaps/slats during the takeoff segment of the mission.

TURN/SLIP CORRECTIONS - Compensating maneuvers to correct for unwanted yaw indications.

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/18/90 REV:		WORKING	READER	DATE	CONTEXT: DG-14 A232
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			



NODE: FACT A2321	TITLE: CAPTURE AIRCRAFT FLIGHT DATA	NUMBER: DG- 42

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A2321:

AIRCRAFT IN BEFORE TAKEOFF POSITION - This is an aircraft condition state. The aircraft engines are started, the systems are activated, the aircraft has taxiied to the active runway, and the necessary operational sequence of events have been accomplished that place the aircraft in a before takeoff position.

AVAILABLE AIRCRAFT FLIGHT DATA - This is the flight data that is generated from within the aircraft. It includes the data that represents the attitude, altitude, velocity, heading, and configuration of the aircraft.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions, etc.

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear, lif or drag devices.

PITCH ANGLE AND RATE - This is a measurement of the aircraft's pitch angle and rate of pitch angle change (Δ Pitch) during the takeoff segment of the mission. Pitch angle and pitch rate values are provided in degrees and degrees change per second, respectively.

TURN/SLIP - This is a measurement of the aircraft's yaw angle and rate of change of yaw angle (Δ Yaw) as it relates tc the turning and rolling of the aircraft during the takeoff segment of the mission. Yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

NODE: FACT / A2321	TITLE: GLOSSARY: CAPTURE AIRCRAFT FLIGHT DATA	NUMBER: DGT-23

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A2321(CONT'D):

ROLL ANGLE AND RATE - This is a measurement of the aircraft's roll angle and rate of roll angle change (Δ Roll) during the takeoff segment of the mission. Roll angle and roll rate values are provided in degrees and degrees change per second, respectively.

INDICATED AIRSPEED - This is a measurement of the aircraft's indicated airspeed during the takeoff segment of the mission. Indicated airspeed is obtained from the pitot-static data provided by the air data computational system. Indicated airspeed is provided in nautical miles per hour or "knots indicated airspeed" (KIAS).

AIRCRAFT ALTITUDE - This is a measurement of the aircraft's altitude during the takeoff segment of the mission. Aircraft altitude may be available from either a barometric source (pressure altimeter) or above-ground-level (AGL) source provided by the radar altimeter.

VERTICAL VELOCITY - This is a measurement of the aircraft's ascent or descent rate during the takeoff segment of the mission. Aircraft vertical velocity is provided in feet-per-minute (FPM) change. Aircraft vertical velocity may be determined from a variety of sources: change in barometric altitude per minute, change in absolute altitude per minute, or a discrete measurement of actual vertical acceleration using precision accelerometers.

INDICATED AIRCRAFT HEADING - This a measurement of the aircraft's magnetic heading during the takeoff segment of the mission. Aircraft magnetic heading is provided in degrees (0-359) and increments of degrees for precision navigational computations.

NODE: FACT / A2321 (CONT'D)	TITLE: GLOSSARY: CAPTURE AIRCRAFT FLIGHT DATA	NUMBER: DGT-24

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/20/90 REV:	WORKING	READER	DATE	CONTEXT: DG-14
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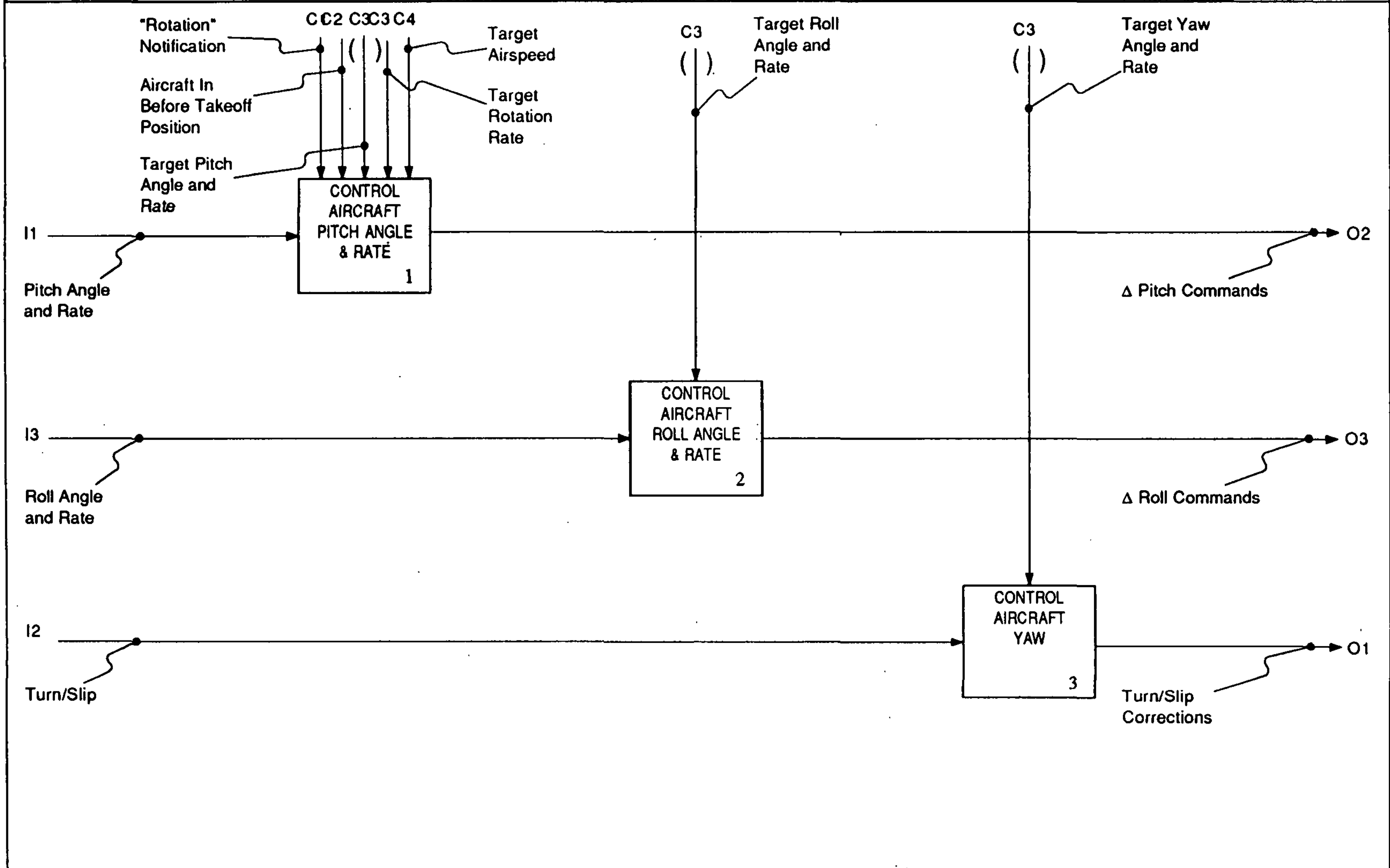
			RECOMMENDED			
			PUBLICATION			A232



NODE: FACT A2322	TITLE: CONTROL AIRCRAFT ATTITUDE	NUMBER: DG-15

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A2322:

"ROTATION" NOTIFICATION - The point at which the aircraft pitch attitude is rotated to the takeoff attitude is notifiec the flight deck crew. At this point the aircraft is rotated to the pre-determined takeoff rotation attitude at the specified rotation rate.

PITCH ANGLE AND RATE - This is a measurement of the aircraft's pitch angle and rate of pitch angle change (Δ Pitch) during the takeoff segment of the mission. Pitch angle and pitch rate values are provided in degrees and degrees change per second, respectively.

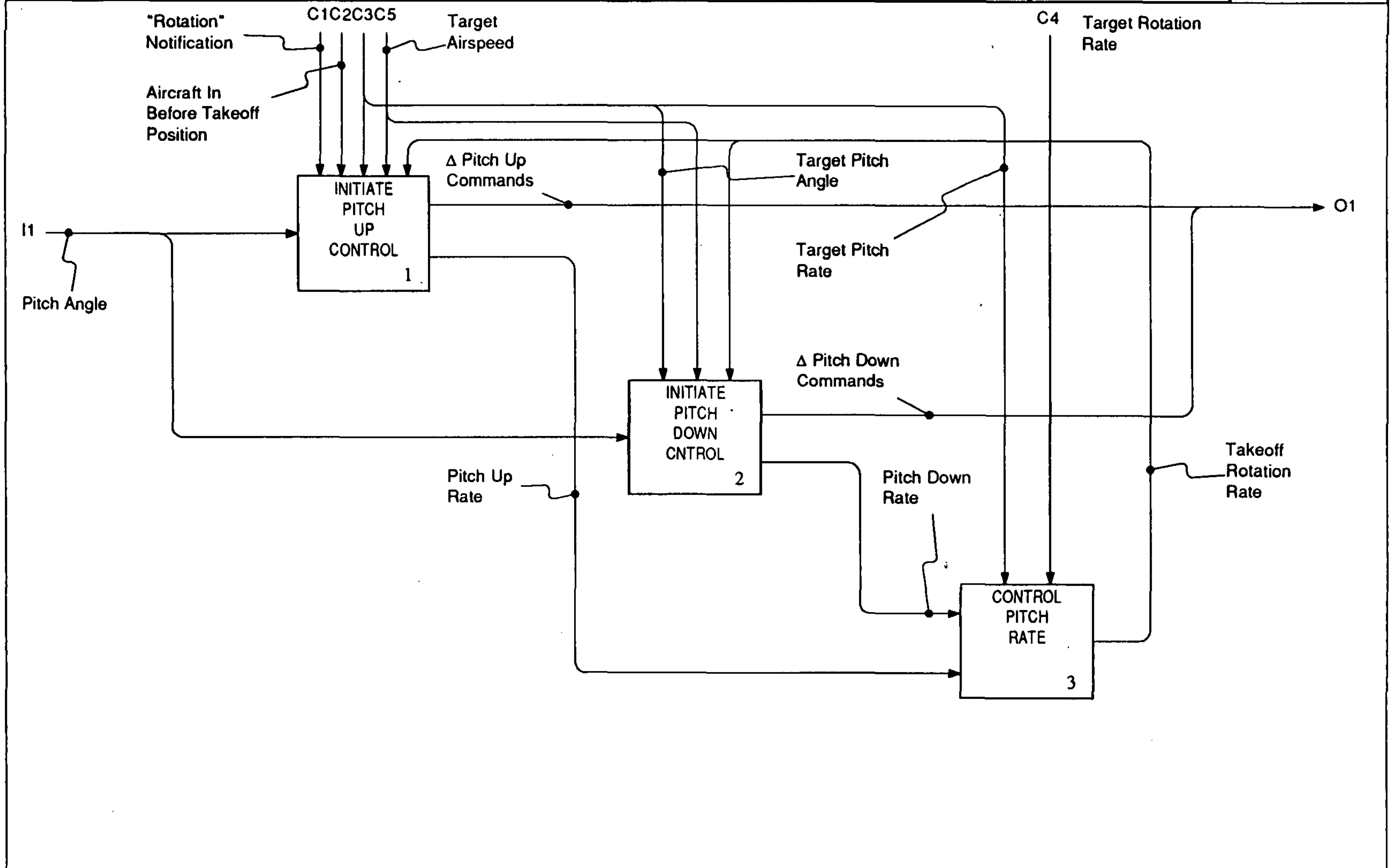
TURN/SLIP - This is a measurement of the aircraft's yaw angle and rate of change of yaw angle (Δ Yaw) as it relates the turning and rolling of the aircraft during the takeoff segment of the mission. Yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

ROLL ANGLE AND RATE - This is a measurement of the aircraft's roll angle and rate of roll angle change (Δ Roll) during the takeoff segment of the mission. Roll angle and roll rate values are provided in degrees and degrees change per second, respectively.

AIRCRAFT IN BEFORE TAKEOFF POSITION - This is an aircraft condition state. The aircraft engines are started, thi systems are activated, the aircraft has taxiied to the active runway, and the necessary operational sequence of events have been accomplished that place the aircraft in a before takeoff position.

NODE: FACT A2322:	TITLE: GLOSSARY: CONTROL AIRCRAFT ATTITUDE	NUMBER: DGT-25

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/20/90 REV:		WORKING	READER DATE	CONTEXT: DG-15 A2322
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		



NODE: FACT A23221	TITLE: CONTROL AIRCRAFT PITCH ANGLE & RATE	NUMBER: DG-16

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23221:

Δ PITCH UP COMMANDS - This is a command to change the pitch angle in an upward direction.

Δ PITCH DOWN COMMANDS - This is a command to change the pitch angle in an downward direction.

PITCH UP RATE - This is the rate of pitch change in an upward direction.

PITCH DOWN RATE - This is the rate of roll change in a downward direction.

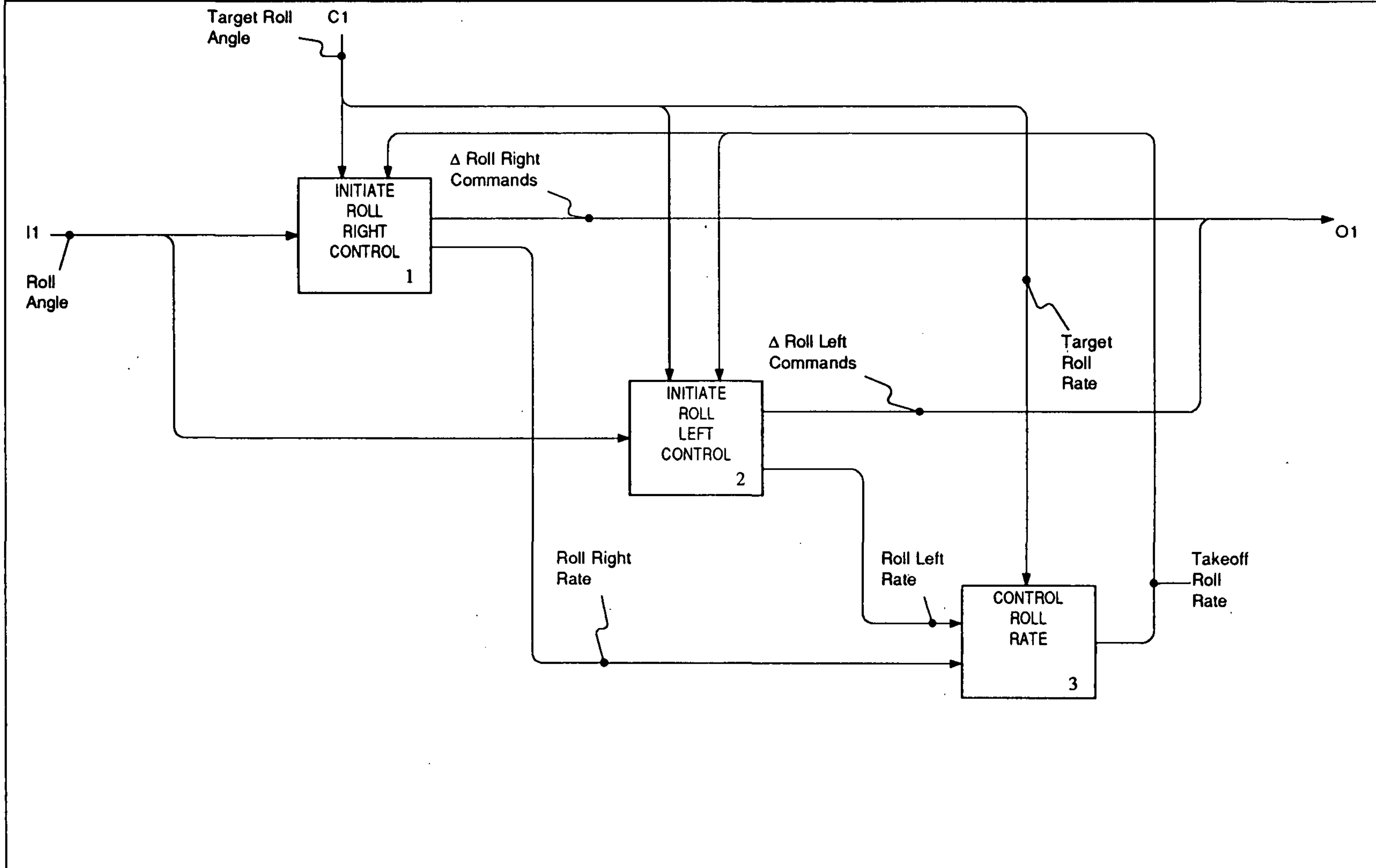
TARGET PITCH ANGLE - This is the "target" or desired pitch angle required for this segment of the mission.

TARGET PITCH RATE - This is the "target" or desired pitch rate required for this segment of the mission.

TAKEOFF ROTATION RATE - The rate of rotation (pitch attitude change) at aircraft lift-off.

NODE: FACT / A23221	TITLE: GLOSSARY: CONTROL AIRCRAFT PITCH ANGLE AND RATE	NUMBER: DGT-26

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/20/90 REV:		WORKING	READER	DATE	CONTEXT: DG-15
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2322



NODE: FACT A23222	TITLE: CONTROL AIRCRAFT ROLL ANGLE & RATE	NUMBER: DG-17

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23222:

ROLL ANGLE - This is a measurement of the aircraft's roll angle during the takeoff segment of the mission. Roll angle values are provided in degrees.

Δ ROLL LEFT COMMANDS - This is a command to change the roll angle in the left direction.

Δ ROLL RIGHT COMMANDS - This is a command to change the roll angle in the right direction.

ROLL LEFT RATE - This is the rate of roll change in the left direction.

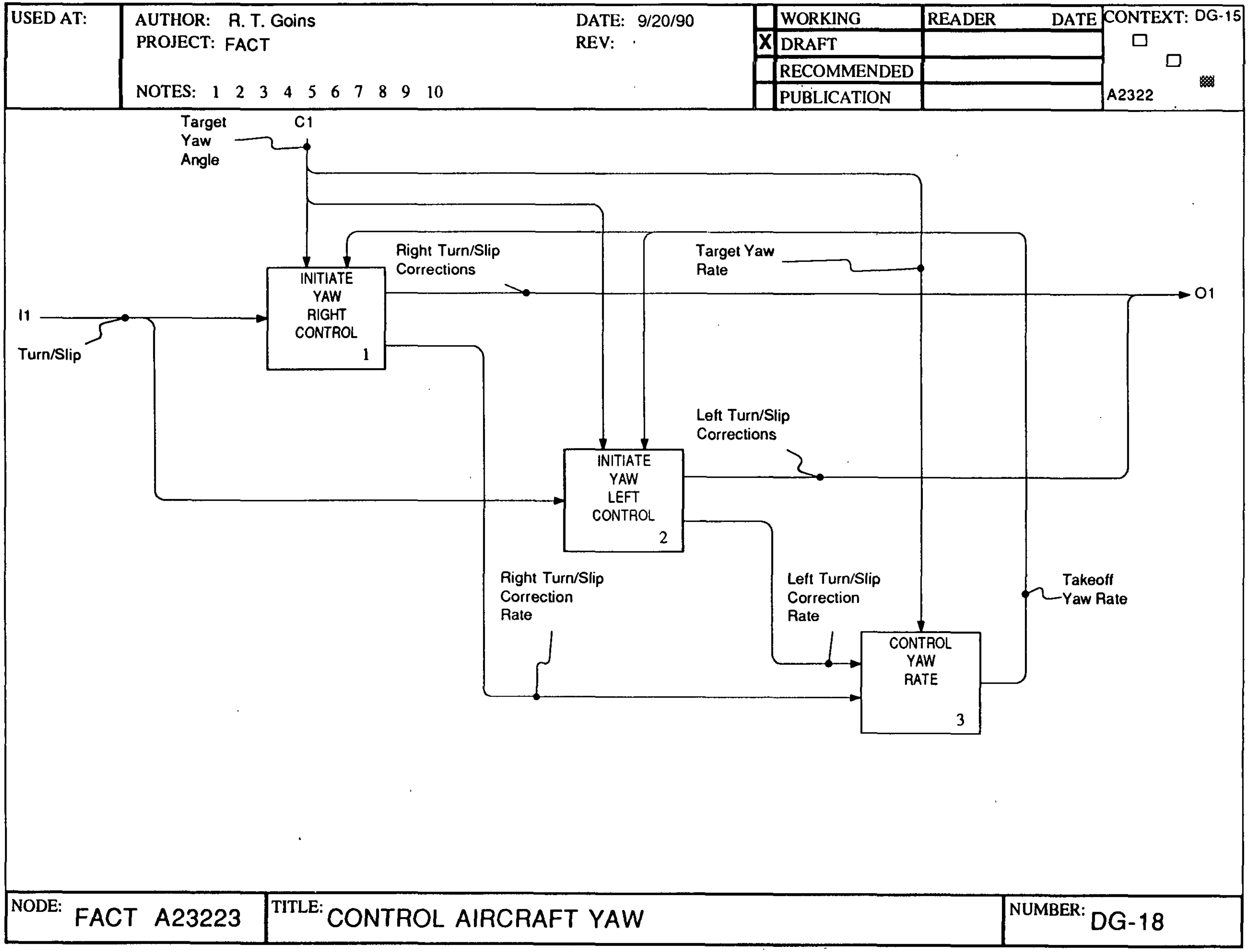
ROLL RIGHT RATE - This is the rate of roll change in the right direction.

TARGET ROLL ANGLE - This is the "target" or desired roll angle required for this segment of the mission.

TARGET ROLL RATE - This is the "target" or desired roll rate required for this segment of the mission.

TAKEOFF ROLL RATE - The rate of roll (roll attitude change) at aircraft lift-off.

NODE: FACT / A23222	TITLE: GLOSSARY: CONTROL AIRCRAFT ROLL ANGLE AND RATE	NUMBER: DGT-27


USED AT:
AUTHOR: R. T. Goins
PROJECT: FACT
DATE: 9/20/90
REV:
NOTES: 1 2 3 4 5 6 7 8 9 10
WORKING
X DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT: DG-15
A2322
Target Yaw Angle
C1
I1
Turn/Slip
INITIATE YAW RIGHT CONTROL
1
Right Turn/Slip Corrections
Target Yaw Rate
O1
INITIATE YAW LEFT CONTROL
2
Left Turn/Slip Corrections
Right Turn/Slip Correction Rate
Left Turn/Slip Correction Rate
Takeoff Yaw Rate
CONTROL YAW RATE
3
NODE: FACT A23223
TITLE: CONTROL AIRCRAFT YAW
NUMBER: DG-18

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23223:

TURN/SLIP - This is a measurement of the aircraft's yaw angle and rate of change of yaw angle (Δ Yaw) as it relates t the turning and rolling of the aircraft during the takeoff segment of the mission. Yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

TARGET YAW ANGLE - This is the "target" or desired yaw angle required for this segment of the mission.

RIGHT TURN/SLIP CORRECTIONS - These are corrections being applied for the right yaw condition.

LEFT TURN/SLIP CORRECTIONS - These are corrections being applied for the left yaw condition.

TARGET YAW RATE - This is the "target" or desired yaw rate required for this segment of the mission.

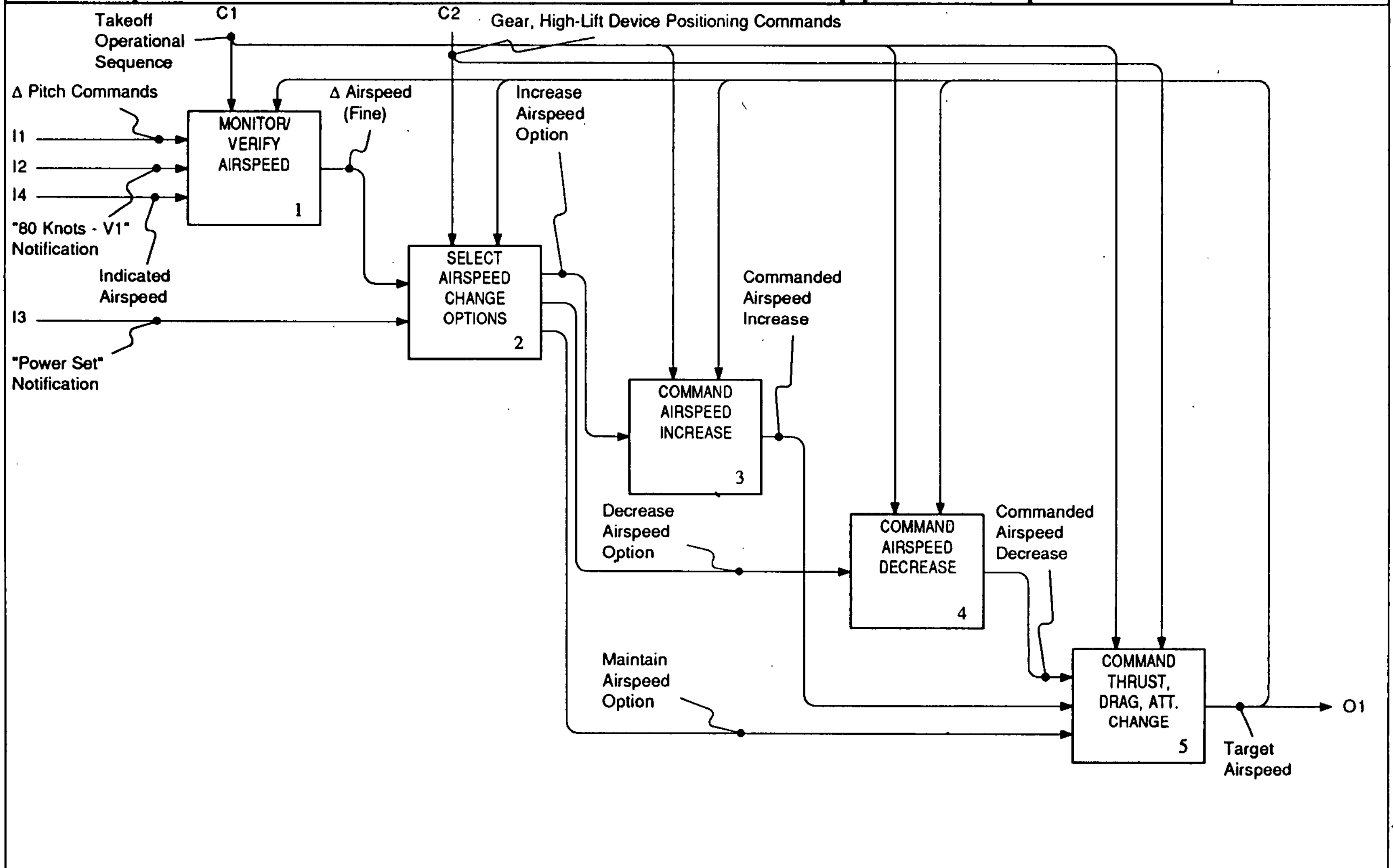
RIGHT TURN/SLIP CORRECTION RATE - This is the rate of turn/slip correction being applied for the right yaw condition.

LEFT TURN/SLIP CORRECTION RATE - This is the rate of turn/slip correction being applied for the left yaw condition

TAKEOFF YAW RATE - The rate of yaw (yaw attitude change) at aircraft lift-off

NODE: FACT / A23223	TITLE: GLOSSARY: CONTROL AIRCRAFT YAW	NUMBER: DGT-28

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/20/90 REV:		WORKING DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-14 A232
			 X 			



NODE: FACT A2323	TITLE: CONTROL AIRCRAFT AIRSPEED	NUMBER: DG-19

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A2323:

Δ AIRSPEED (FINE) - The fine changes being applied as a correction to control the aircraft airspeed.

INCREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed increase.

DECREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed decrease.

MAINTAIN AIRSPEED OPTION - This is the airspeed change option that allows the existing airspeed to be maintained.

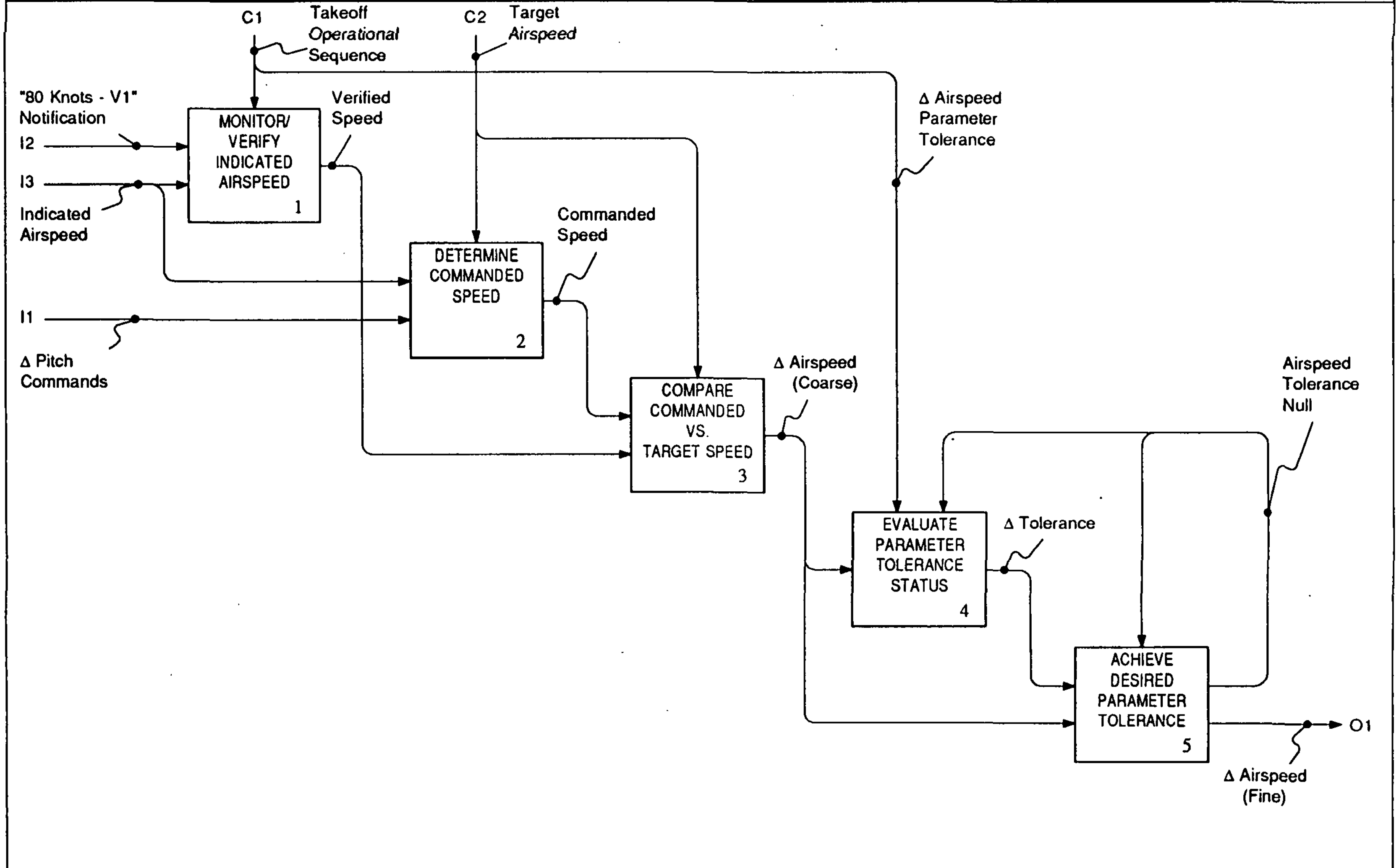
COMMANDED AIRSPEED INCREASE - This command directs an increase in aircraft airspeed.

COMMANDED AIRSPEED DECREASE - This command directs a decrease in aircraft airspeed.

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

NODE: FACT / A2323	TITLE: GLOSSARY: CONTROL AIRCRAFT AIRSPEED	NUMBER: DGT-29

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER	DATE	CONTEXT: DG-19 A2323
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			



NODE: FACT A23231	TITLE: MONITOR/ VERIFY AIRSPEED	NUMBER: DG-20

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23231:

VERIFIED SPEED - This is a verification or confirmation of the speed of the aircraft at this time during this segment of the mission.

COMMANDED SPEED - This is the speed that the aircraft has been commanded to attain during this segment of the mission.

Δ AIRSPEED (COARSE) - This is the coarse comparison between the commanded versus the desired airspeed.

Δ AIRSPEED PARAMETER TOLERANCE - This is the allowable tolerance of the comparison between the commanded versus the desired airspeed.

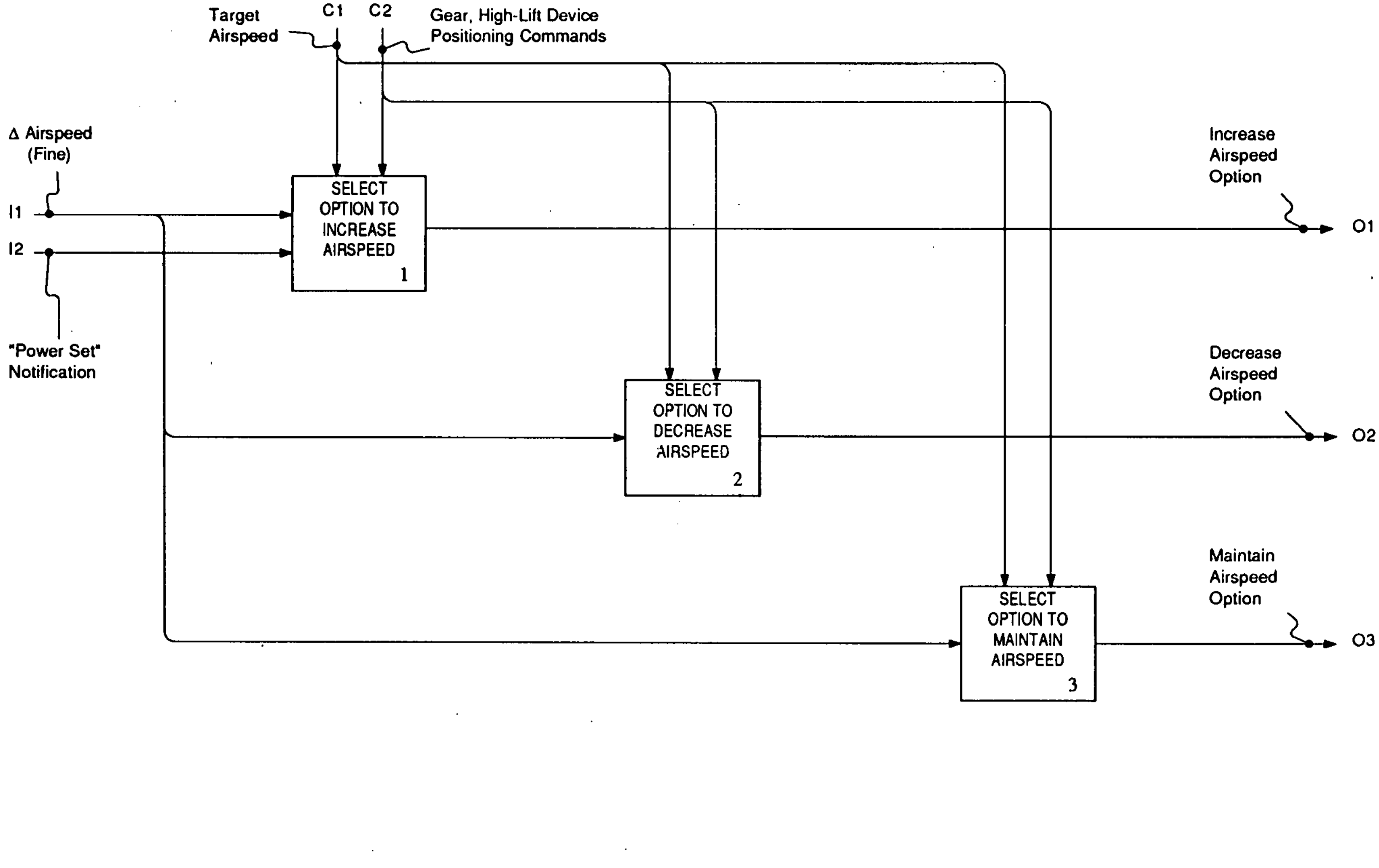
Δ TOLERANCE - If the Δ AIRSPEED PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

AIRSPEED TOLERANCE NULL - The "nulling" of the airspeed change loop.

Δ AIRSPEED (FINE) - The fine changes being applied as a correction to control the aircraft airspeed.

NODE: FACT / A23231	TITLE: GLOSSARY: MONITOR/VERIFY AIRSPEED	NUMBER: DGT-30

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER	DATE	CONTEXT: DG-19
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2323



NODE: FACT A23232	TITLE: SELECT AIRSPEED CHANGE OPTIONS	NUMBER: DG-21

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23232:

Δ AIRSPEED (FINE) - The fine changes being applied as a correction to control the aircraft airspeed.

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed ma' be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the lift or drag devices.

"POWER SET" NOTIFICATION - This notifies the flight deck crew that the takeoff power setting has been accomplished

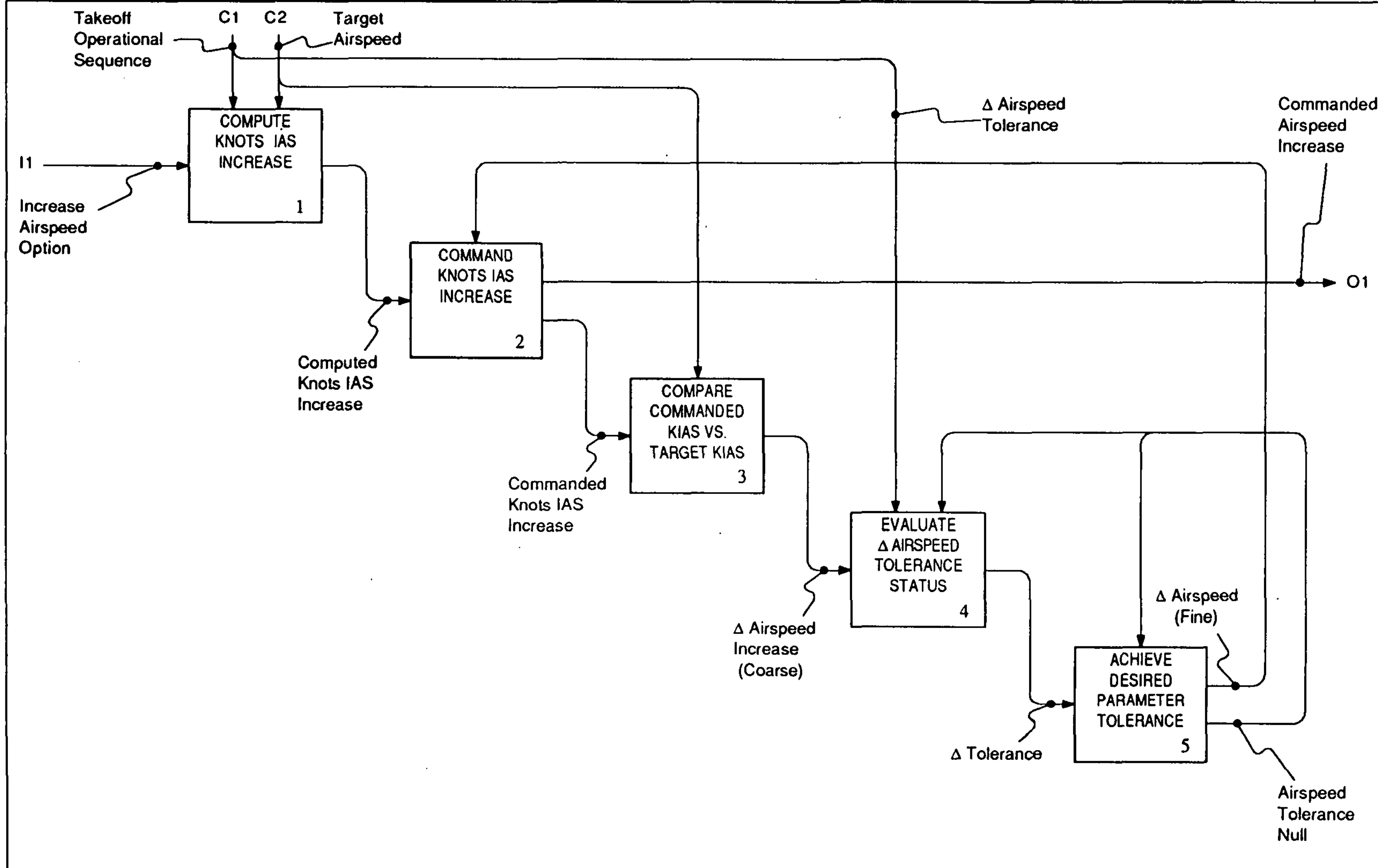
INCREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed increase.

DECREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed decrease.

MAINTAIN AIRSPEED OPTION - This is the airspeed change option that allows the existing airspeed to be maintained.

NODE: FACT / A23232	TITLE: GLOSSARY: SELECT AIRSPEED CHANGE OPTIONS	NUMBER: DGT-31

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER . DATE	CONTEXT: DG-19 A2323
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		



NODE: FACT A23233	TITLE: COMMAND AIRSPEED INCREASE	NUMBER: DG-22

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23233:

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

INCREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed increase.

Δ AIRSPEED PARAMETER TOLERANCE - This is the allowable tolerance of the comparison between the commanded versus the desired airspeed.

COMMANDED AIRSPEED INCREASE - This command directs an increase in aircraft airspeed.

COMPUTED KNOTS IAS INCREASE - The knots change in airspeed is computed during this activity.

COMMANDED KNOTS IAS INCREASE - The command to change the aircraft airspeed by the computed amount is provided here.

Δ AIRSPEED INCREASE (COARSE) - This is the *coarse comparison* between the *commanded airspeed increase* versus the target airspeed.

Δ TOLERANCE - If the Δ AIRSPEED PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

NODE: FACT / A23233	TITLE: GLOSSARY: COMMAND AIRSPEED INCREASE	NUMBER: DGT-32

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23233 (CONT'D):

Δ AIRSPEED (FINE) - The fine airspeed increases being applied as a correction to control the aircraft airspeed.

AIRSPEED TOLERANCE NULL - The "nulling" of the airspeed change loop.

NODE: FACT /A23233 (CONT'D)	TITLE: GLOSSARY: COMMAND AIRSPEED INCREASE	NUMBER: DGT-33

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER	DATE	CONTEXT: DG-19
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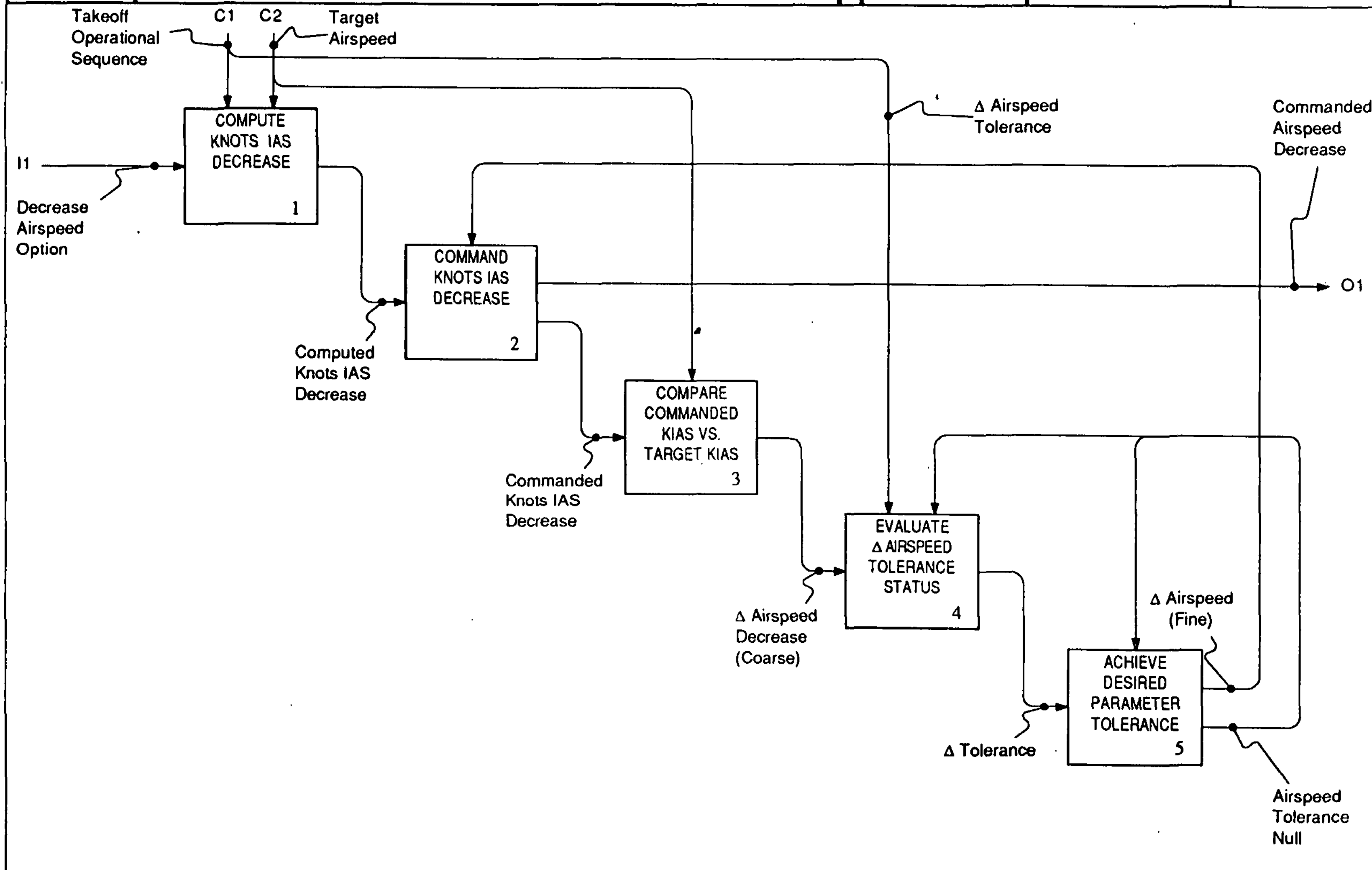
				RECOMMENDED			
				PUBLICATION			A2323



NODE: FACT A23234	TITLE: COMMAND AIRSPEED DECREASE	NUMBER: DG-23

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23234:

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

DECREASE AIRSPEED OPTION - This is the airspeed change option that allows for the command of an airspeed decrease.

Δ AIRSPEED PARAMETER TOLERANCE - This is the allowable tolerance of the comparison between the commanded versus the desired airspeed.

COMMANDED AIRSPEED DECREASE - This command directs a decrease in aircraft airspeed.

COMPUTED KNOTS IAS DECREASE - The knots change in airspeed is computed during this activity.

COMMANDED KNOTS IAS DECREASE - The command to change the aircraft airspeed by the computed amount is provided here.

Δ AIRSPEED DECREASE (COARSE) - This is the coarse comparison between the commanded airspeed decrease versus the target airspeed.

Δ TOLERANCE - If the Δ AIRSPEED PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

NODE: FACT / A23234	TITLE: GLOSSARY: COMMAND AIRSPEED DECREASE	NUMBER: DGT-34

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

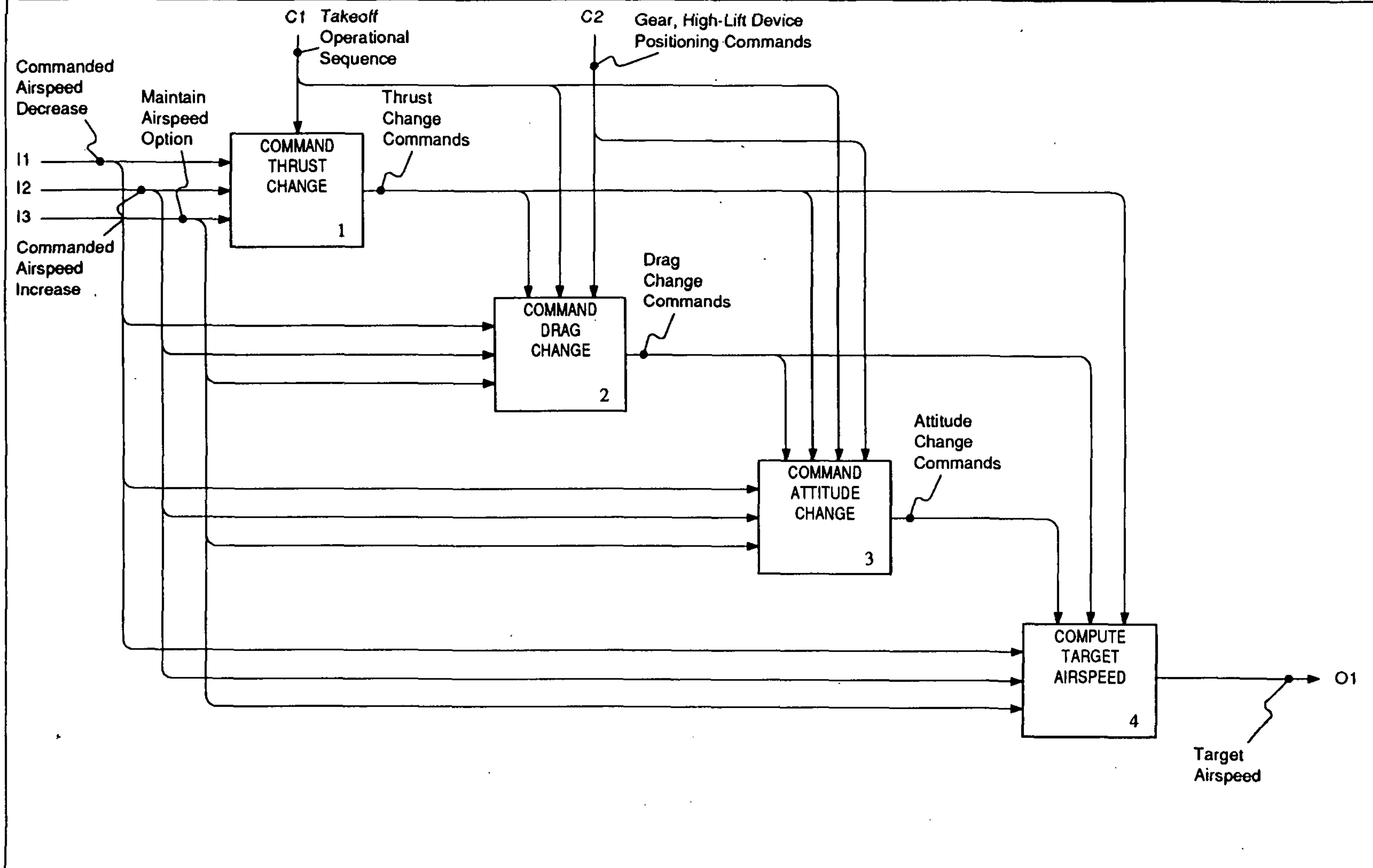
GLOSSARY - FACT A23234 (CONT'D):

Δ AIRSPEED (FINE) - The fine airspeed decreases being applied as a correction to control the aircraft airspeed.

AIRSPEED TOLERANCE NULL - The "nulling" of the airspeed change loop.

NODE: FACT /A 23234 (CONT'D)	TITLE: GLOSSARY: COMMAND AIRSPEED DECREASE	NUMBER: DGT-35

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER DATE	CONTEXT: DG-19
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		A2323



NODE: FACT A23235	TITLE: COMMAND THRUST, DRAG, ATT. CHANGE	NUMBER: DG-24

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23235:

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the lift or drag devices.

MAINTAIN AIRSPEED OPTION - This is the airspeed change option that allows the existing airspeed to be maintained.

COMMANDED KNOTS IAS DECREASE - The command to decrease the aircraft airspeed by the computed amount is provided here.

COMMANDED KNOTS IAS INCREASE - The command to increase the aircraft airspeed by the computed amount is provided here.

THRUST CHANGE COMMANDS - Commands to change the thrust (propulsion) are provided through this activity.

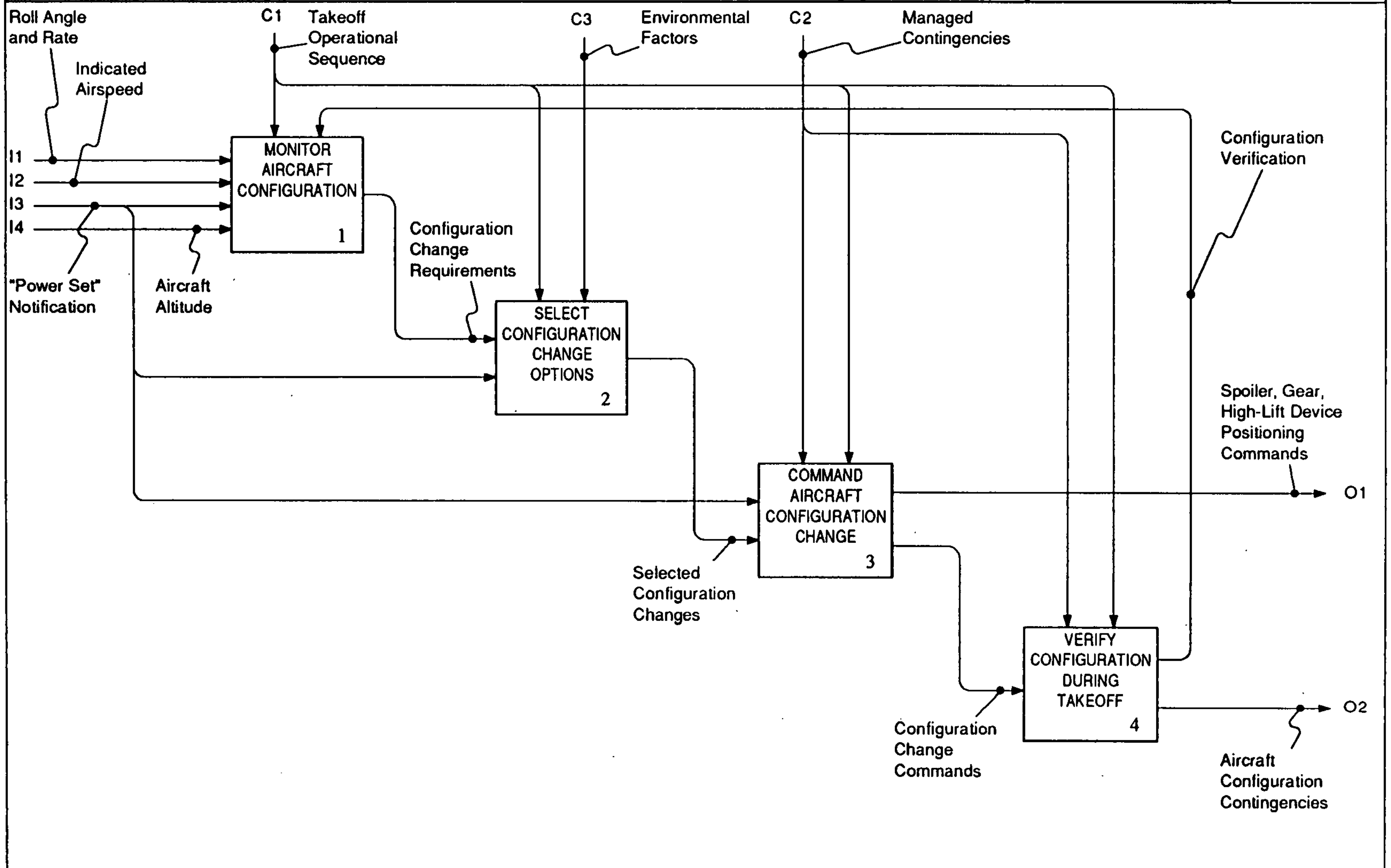
DRAG CHANGE COMMANDS - Commands to change the drag on the aircraft are provided through this activity.

ATTITUDE CHANGE COMMANDS - Commands to change the aircraft attitude in either or all of the three axes (pitch, roll, and yaw) are provide through this activity.

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

NODE: FACT / A23235	TITLE: GLOSSARY: COMMAND THRUST, DRAG, ATTITUDE CHANGE	NUMBER: DGT-36

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-14 A232



NODE: FACT A2324	TITLE: CONTROL AIRCRAFT CONFIGURATION	NUMBER: DG-25

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A2324:

CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft based upon the current configuration and that that is required maintain a specified flight attitude, altitude, and airspeed during this segment of the mission.

SELECTED CONFIGURATION CHANGES - These are the configuration changes that have been selected as a result of this activity.

CONFIGURATION CHANGE COMMANDS - The commands to change the aircraft configuration are generated as a result of this activity.

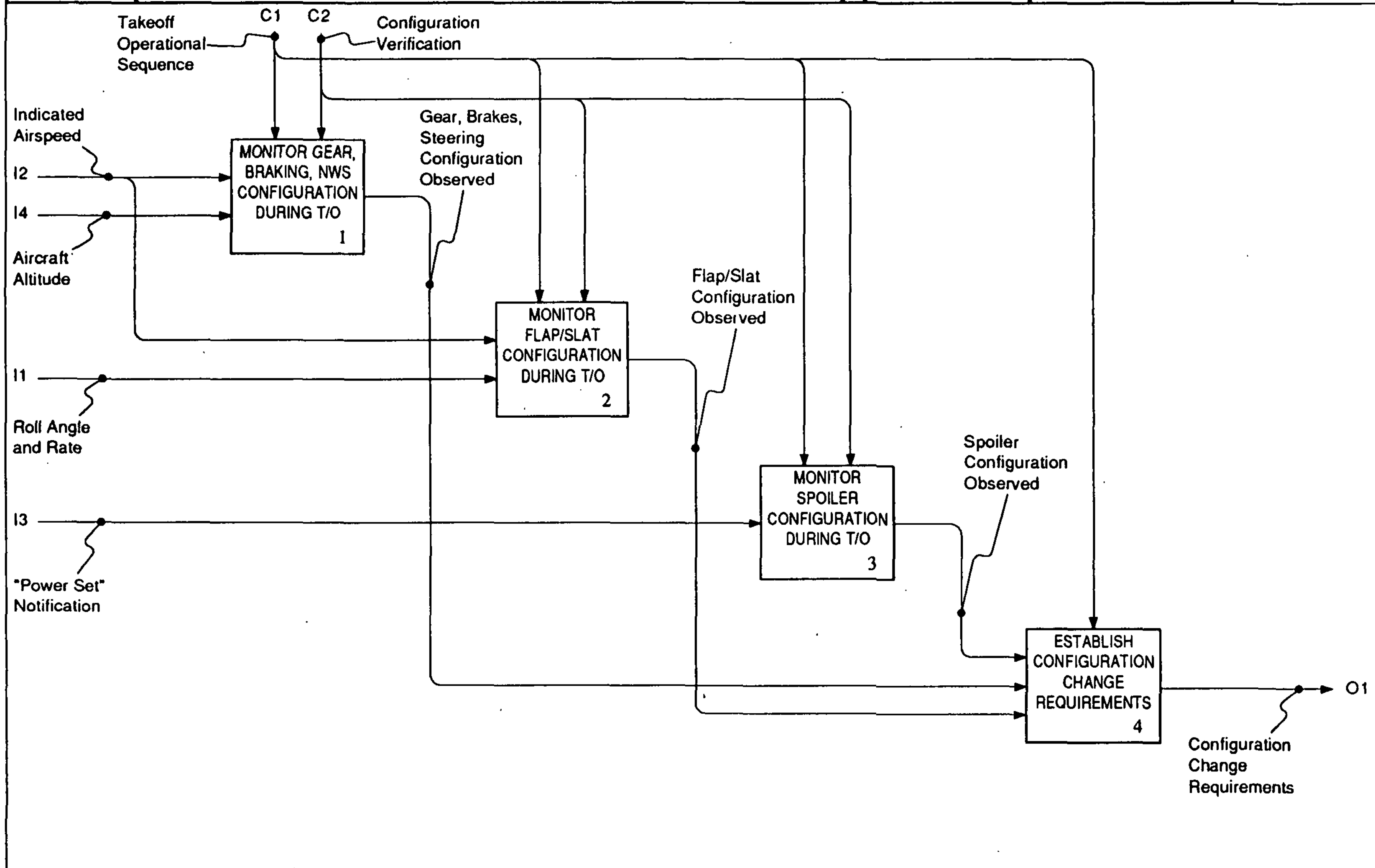
SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the lift or drag devices.

CONFIGURATION VERIFICATION - This is the feedback to the "Monitor Aircraft Configuration" function. This activity verifies or confirms that the commanded configuration change occurred as required.

AIRCRAFT CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the flight control configuration of the aircraft. Contingencies in this category may be those related to the retraction or extension of the spoilers, landing gear, or the flaps/slats during the takeoff segment of the mission.

NODE: FACT / A2324	TITLE: GLOSSARY: CONTROL AIRCRAFT CONFIGURATION	NUMBER: DGT-37

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER	DATE	CONTEXT: DG-25
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2324



NODE: FACT A23241	TITLE: MONITOR AIRCRAFT CONFIGURATION	NUMBER: DG-26

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23241:

GEAR, BRAKES, STEERING, CONFIGURATION OBSERVED -Observations indicating the status of either the landing gear, aircraft braking system, or the aircraft ground steering system or any combination of these systems.

FLAP/SLAT CONFIGURATION OBSERVED - Observations indicating the status of either the high-lift device systems.

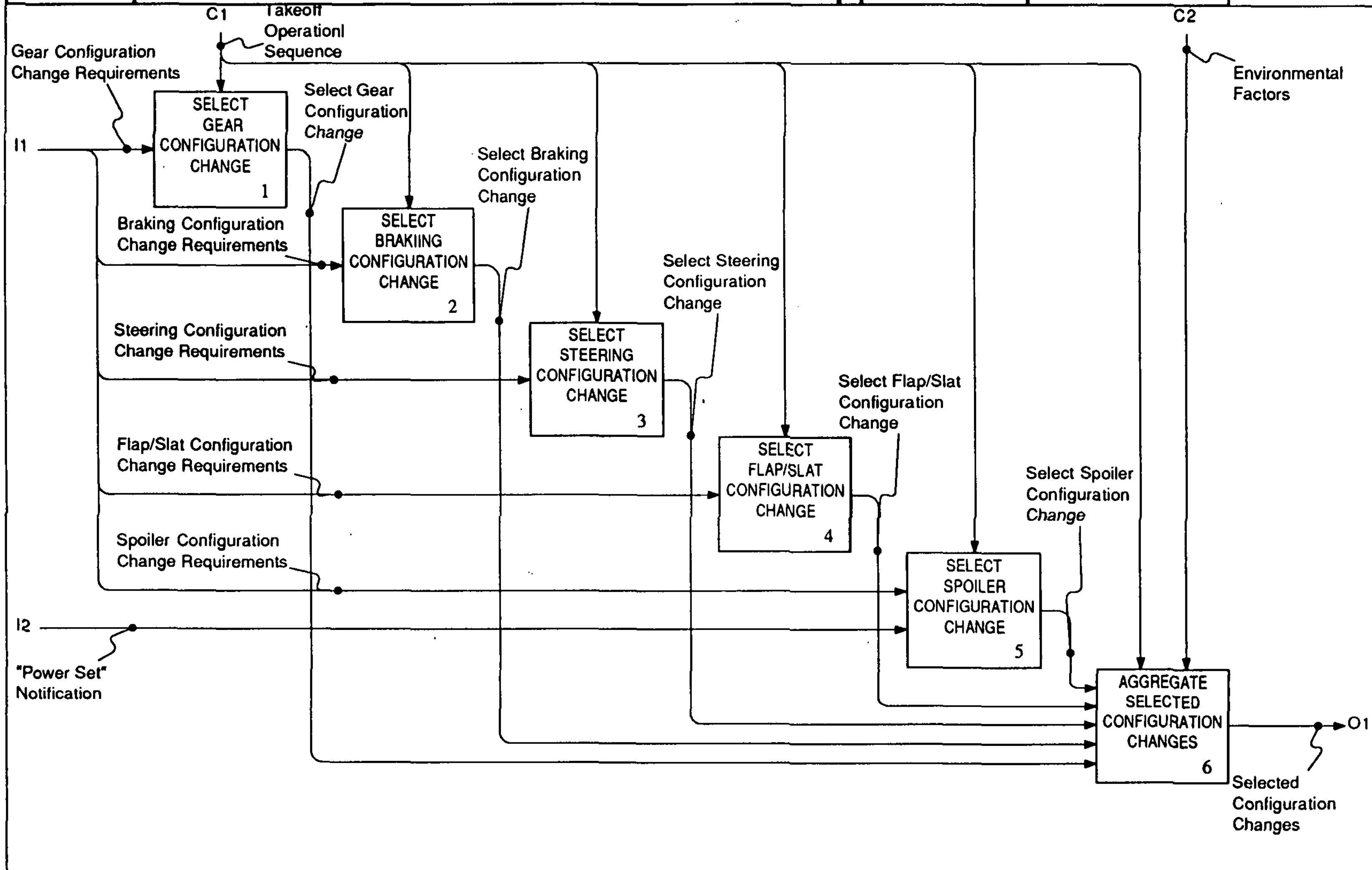
SPOILER CONFIGURATION OBSERVED - Observations indicating the status of the spoiler system.

CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft based upon the current configuration and that that is required maintain a specified flight attitude, altitude, and airspeed during this segment of the mission.

NODE: FACT / A23241	TITLE: GLOSSARY: MONITOR AIRCRAFT CONFIGURATION	NUMBER: DGT-38

C-4

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-25 A2324



NODE: FACT A23242	TITLE: SELECT CONFIGURATIONCHANGE OPTIONS	NUMBER: DG-27

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23242:

GEAR CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft landing gear system based upon the current configuration and that required to maintain a specified flight attitude, altitude, and airspeed during this segment of the mission.

STEERING CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft ground steering system based upon the current configuration and that required to maintain a specified runway centerline/direction during this segment of the mission.

BRAKING CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft braking system based upon the current configuration and that required to maintain a specified braking distance during this segment of the mission.

FLAP/SLAT CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft flap/slat system based upon the current configuration and that required to maintain a specified flight attitude, altitude, and airspeed during this segment of the mission.

SPOILER CONFIGURATION CHANGE REQUIREMENTS - These are the requirements to change the configuration of the aircraft spoiler system based upon the current configuration and that required to maintain a specified flight attitude, altitude, and airspeed during this segment of the mission.

SELECT GEAR CONFIGURATION CHANGE - This is the configuration change selection that affects the landing gear retraction or extension during this segment of the mission..

NODE: FACT / A23242	TITLE: GLOSSARY: SELECT CONFIGURATION CHANGE OPTIONS	NUMBER: DGT-39

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23242 (CONT'D)

SELECT BRAKING CONFIGURATION CHANGE - This is the configuration change selection that affects the braking system.

SELECT STEERING CONFIGURATION CHANGE - This is the configuration change selection that affects the steering system.

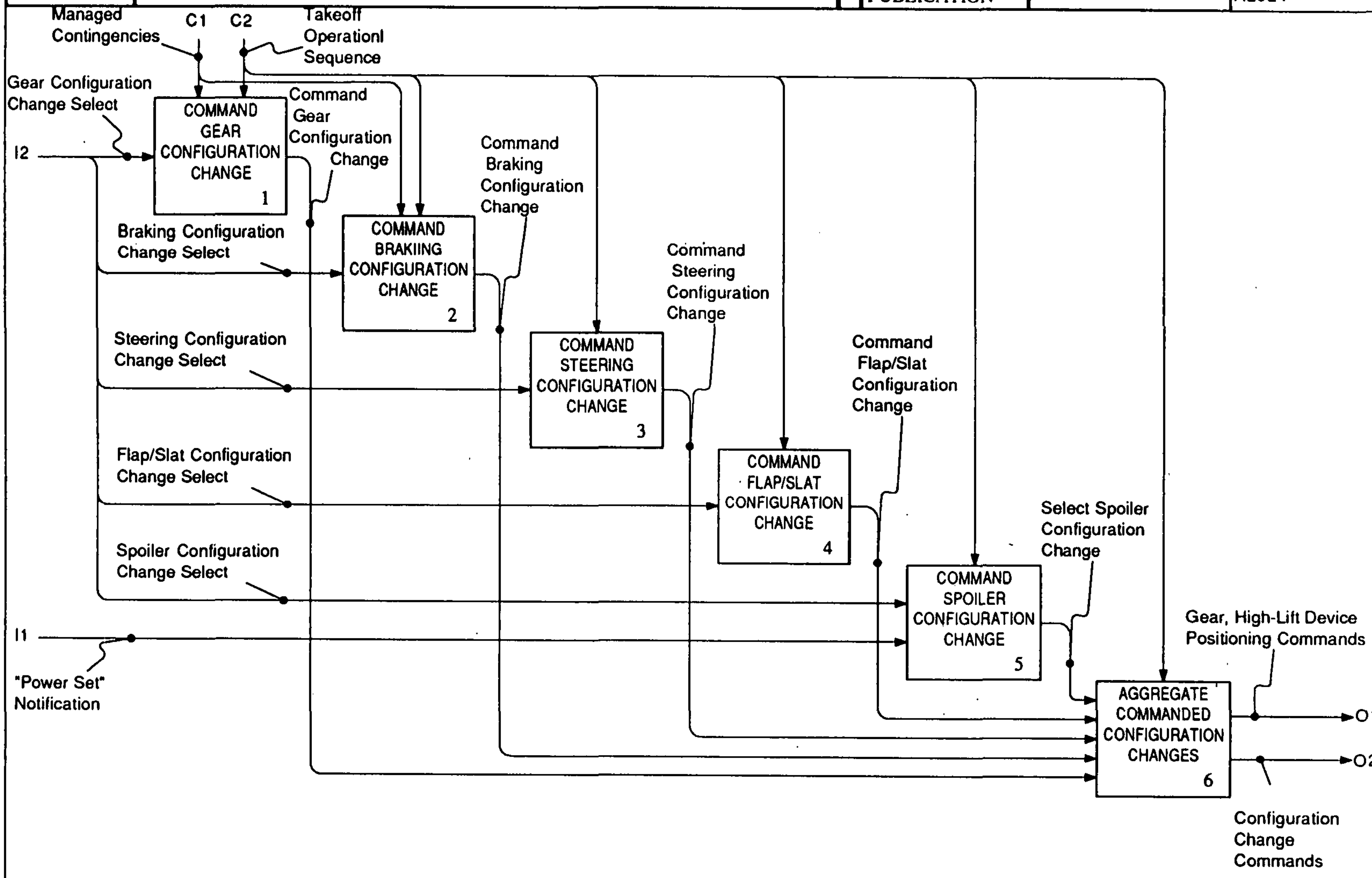
SELECT FLAP/SLAT CONFIGURATION CHANGE - This is the configuration change selection that affects the flap/slat retraction or extension during this segment of the mission.

SPOILER CONFIGURATION CHANGE - This is the configuration change selection that affects the retraction or extension of the spoilers during this segment of the mission.

SELECTED CONFIGURATION CHANGES - These are the combined configuration changes that have been selected as a result of this activity.

NODE: FACT /A23242 (CONT'D)	TITLE: GLOSSARY: SELECT CONFIGURATION CHANGE OPTIONS	NUMBER: DGT-40

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER DATE	CONTEXT: DG-25
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		A2324



NODE: FACT A23243	TITLE: COMMAND AIRCRAFT CONFIGURATIONCHANGE	NUMBER: DG-28

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/27/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23243:

GEAR CONFIGURATION CHANGE SELECT- This activity selects the command required to initiate the configuration change of the landing gear during this segment of the mission.

BRAKING CONFIGURATION CHANGE SELECT - This activity selects the command required to initiate the configuration change of the braking system during this segment of the mission.

STEERING CONFIGURATION CHANGE SELECT - This activity selects the command required to initiate the configuration change of the steering system during this segment of the mission.

FLAP/SLAT CONFIGURATION CHANGE SELECT- This activity selects the command required to initiate the configuration change of the flap/slats during this segment of the mission.

SPOILER CONFIGURATION CHANGE SELECT- This activity selects the command required to initiate the configuration change of the spoilers during this segment of the mission.

COMMAND GEAR CONFIGURATION CHANGE - This activity provides the command that initiates landing gear retraction or extension during this segment of the mission.

COMMAND BRAKING CONFIGURATION CHANGE - This activity provides the command that initiates the braking system during this segment of the mission.

COMMAND STEERING CONFIGURATION CHANGE - This activity provides the command that initiates the steering system during this segment of the mission.

NODE: FACT / A23243	TITLE: GLOSSARY: COMMAND AIRCRAFT CONFIGURATION CHANGE	NUMBER: DGT-41

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23243 (CONT'D):

COMMAND FLAP/SLAT CONFIGURATION CHANGE - This activity provides the command that initiates the configuration change of the flap/slats during this segment of the mission.

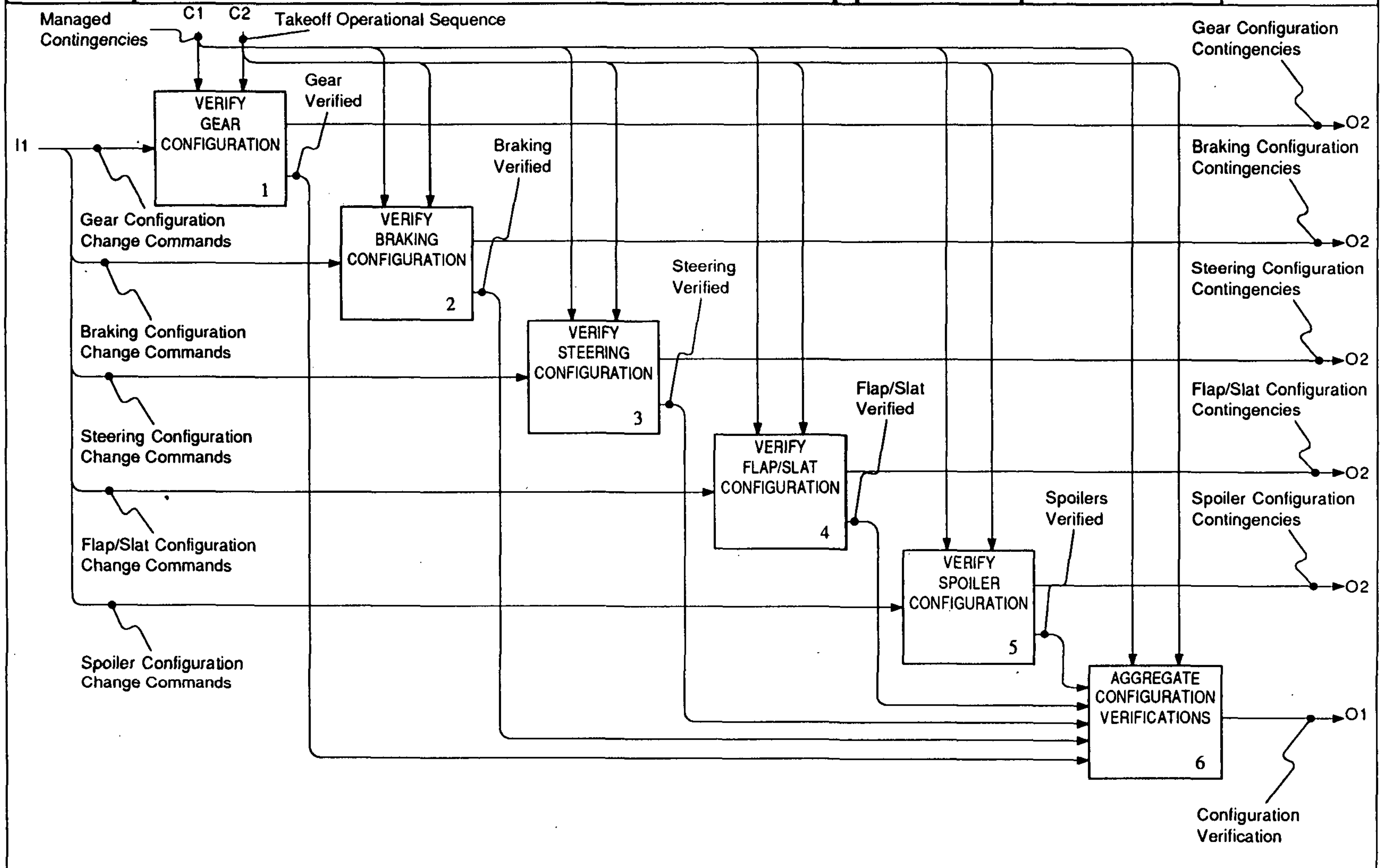
COMMAND SPOILER CONFIGURATION CHANGE - This activity provides the command that initiates spoiler retraction or extension during this segment of the mission.

CONFIGURATION CHANGE COMMANDS - The commands to change the aircraft configuration are generated as a result of this activity.

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided eithei automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear and/or lift or drag devices.

NODE: FACT /A23243 (CONT'D)	TITLE: GLOSSARY: COMMAND AIRCRAFT CONFIGURATION CHANGE	NUMBER: DGT- 42

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:		WORKING	READER	DATE	CONTEXT: DG-25
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2324



NODE: FACT A23244	TITLE: VERIFY CONFIGURATIONDURING TAKEOFF	NUMBER: DG-29

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23244:

GEAR CONFIGURATION CHANGE COMMANDS- These are the commands that initiate landing gear retraction or extension during this segment of the mission.

BRAKING CONFIGURATION CHANGE COMMANDS - These are the commands that initiate the braking system during this segment of the mission.

STEERING CONFIGURATION CHANGE COMMANDS- These are the commands that initiate the steering system during this segment of the mission.

FLAP/SLAT CONFIGURATION CHANGE COMMANDS- These are the commands that initiate the configuration change of the flap/slats during this segment of the mission.

SPOILER CONFIGURATION CHANGE COMMANDS - These are the commands that initiate spoiler retraction or extension during this segment of the mission.

GEAR VERIFIED - Verification of the commanded configuration of the landing gear.

BRAKING VERIFIED - Verification of the commanded configuration of the braking system.

STEERING VERIFIED - Verification of the commanded configuration of the steering system.

FLAP/SLAT VERIFIED - Verification of the commanded configuration of the flaps/slats.

NODE: FACT / A23244	TITLE: GLOSSARY: VERIFY CONFIGURATION DURING TAKEOFF	NUMBER: DGT-43

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23244 (CONT'D):

SPOILERS VERIFIED - The commanded configuration of the spoilers are verified through this activity.

GEAR CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the configuration of the aircraft landing gear retraction or extension during this segment of the mission.

BRAKING CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the configuration of the aircraft braking system control during this segment of the mission.

STEERING CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the configuration of the aircraft steering system control during this segment of the mission.

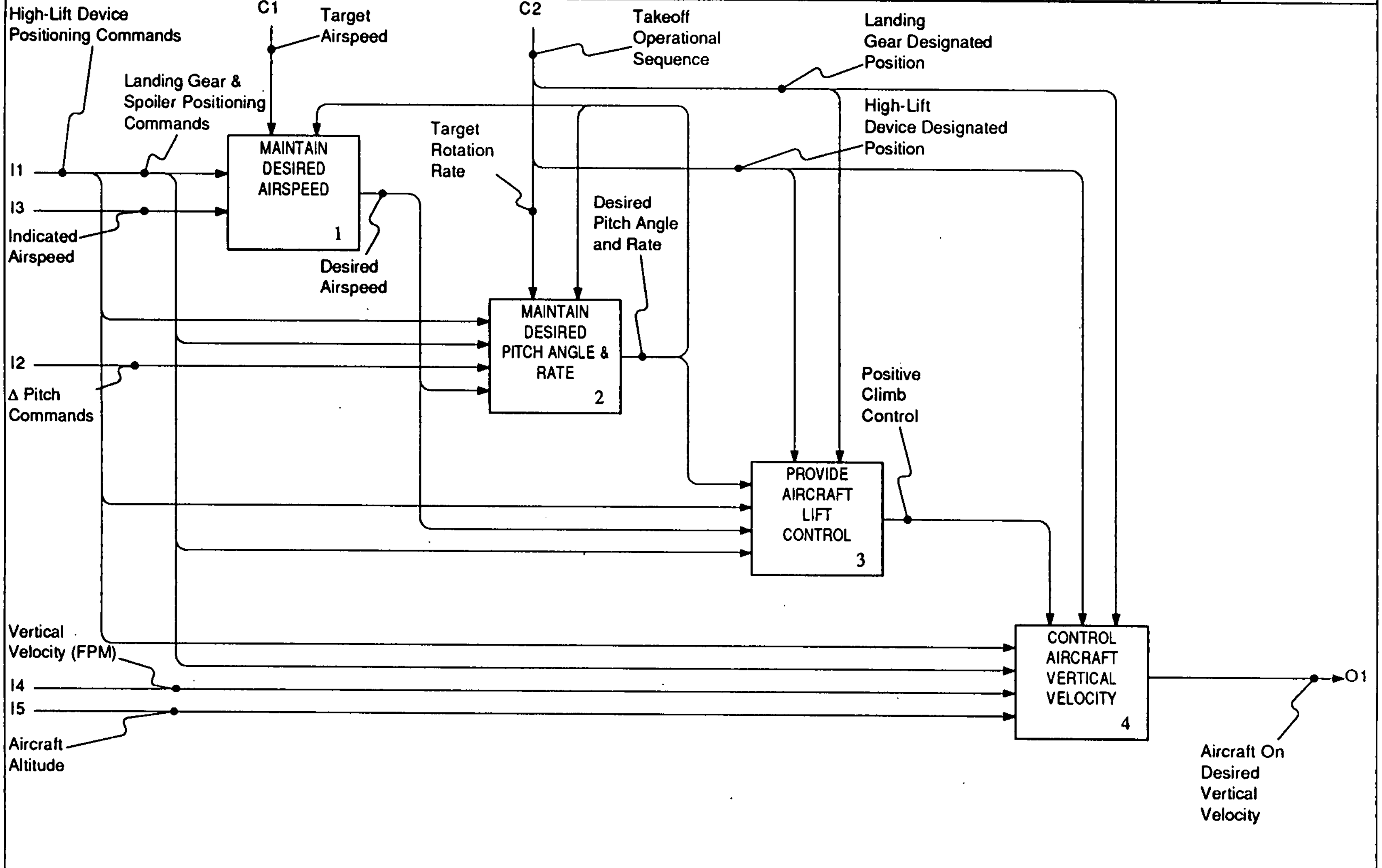
FLAP/SLAT CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the configuration of the flap/slat retraction or extension during this segment of the mission.

SPOILER CONFIGURATION CONTINGENCIES - These are the unexpected events that affect the configuration of the spoiler control during this segment of the mission.

CONFIGURATION VERIFICATION - This is the feedback to the "Monitor Aircraft Configuration" function. This activity verifies or confirms that the commanded configuration change occurred as required.

NODE: FACT /A23244 (CONT'D)	TITLE: GLOSSARY: VERIFY CONFIGURATION DURING TAKEOFF	NUMBER: DGT-44

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/22/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-14 A232



NODE: FACT A2325	TITLE: CONTROL AIRCRAFT ALTITUDE	NUMBER: DG-30

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - *FACT A2325:*

HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the high-lift (flap/slat) devices.

LANDING GEAR & SPOILER POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear or drag devices.

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

TARGET ROTATION RATE - The desired rate of rotation (pitch attitude change) prior to aircraft lift-off.

DESIRED AIRSPEED - This is a desired or "target" airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

INDICATED AIRSPEED - This is a measurement of the aircraft's indicated airspeed during the takeoff segment of the mission. Indicated airspeed is obtained from the pitot-static data provided by the air data computational system. Indicated airspeed is provided in nautical miles per hour or "knots indicated airspeed" (KIAS).

Δ PITCH COMMANDS - This is a command to change pitch angle.

NODE: FACT /A2325	TITLE: GLOSSARY: CONTROL AIRCRAFT ALTITUDE	NUMBER: DGT-45

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A2325 (CONT'D):

VERTICAL VELOCITY (FPM) - This is a measurement of the aircraft's ascent or descent rate during the takeoff segment of the mission. Aircraft vertical velocity is provided in feet-per-minute (FPM) change. Aircraft vertical velocity may be determined from a variety of sources: change in barometric altitude per minute, change in absolute altitude per minute, or a discrete measurement of actual vertical acceleration using precision accelerometers.

AIRCRAFT ALTITUDE - This is a measurement of the aircraft's altitude during the takeoff segment of the mission. Aircraft altitude may be available from either a barometric source (pressure altimeter) or above-ground-level (AGL) source from the radar altimeter.

DESIRED PITCH ANGLE AND RATE - The target pitch angle and rate of pitch angle change during this segment of the mission.

LANDING GEAR DESIGNATED POSITION - The designated position of the aircraft landing gear as specified by the operational sequence for this segment of the mission.

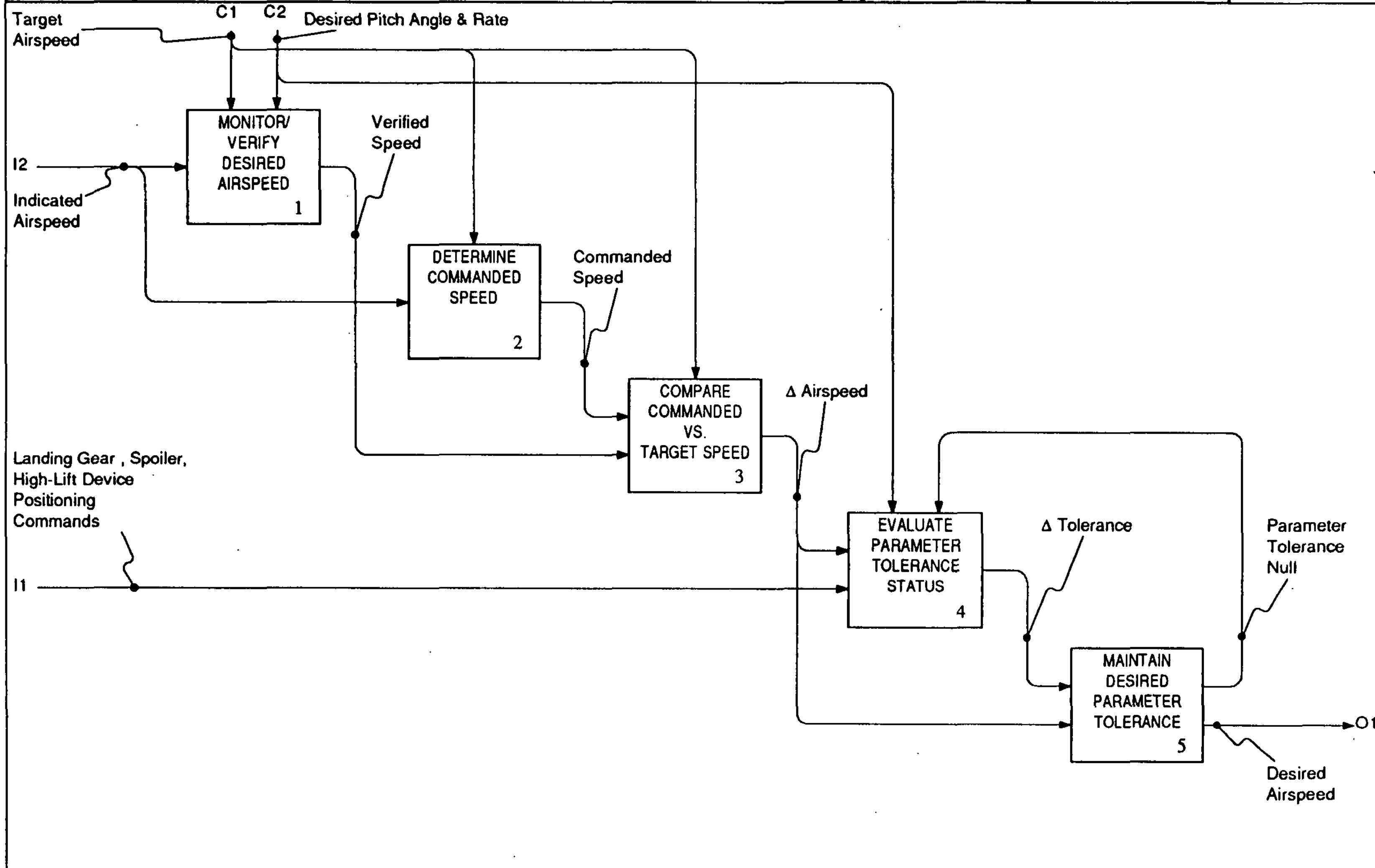
HIGH-LIFT DEVICE DESIGNATED POSITION - The designated position of the high-lift devices (flaps/slats) as specified by the operational sequence for this segment of the mission.

POSITIVE CLIMB CONTROL - The aircraft is now in a positive (up) rate of climb as required by the conditions existing after aircraft liftoff.

AIRCRAFT ON DESIRED VERTICAL VELOCITY - After liftoff, the aircraft's ascent rate (vertical velocity) is controlled required to attain a planned ascent rate, attain or maintain a desired altitude, or clear obstacles within the flight path.

NODE: FACT / A2325 (CONT'D)	TITLE: GLOSSARY: CONTROL AIRCRAFT ALTITUDE	NUMBER: DGT-46

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-30 A2325



NODE: FACT A23251	TITLE: MAINTAIN DESIRED AIRSPEED	NUMBER: DG-31

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23251:

TARGET AIRSPEED - This is a"target" or desired airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

INDICATED AIRSPEED - This is a measurement of the aircraft's indicated airspeed during the takeoff segment of the mission. Indicated airspeed is obtained from the pitot-static data provided by the air data computational system. Indicated airspeed is provided in nautical miles per hour or "knots indicated airspeed" (KIAS).

DESIRED PITCH ANGLE AND RATE - The target pitch angle and rate of pitch angle change during this segment of the mission.

LANDING GEAR, SPOILER, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of th landing gear and/or lift or drag devices.

COMMANDED SPEED - This is the speed that the aircraft has been commanded to attain during this segment of the mission.

Δ AIRSPEED - The difference between the commanded versus the target airspeeds. This difference generates a requirement to adjust the commanded airspeed to be in agreement with the target airspeed. Any remaining differences in airspeed (Δ Airspeed, Δ Tolerance) are used as coarse and fine refinements to produce a "null", or zero difference between the indicated, verified, commanded, and target airspeeds.

NODE: FACT / A23251	TITLE: GLOSSARY: MAINTAIN DESIRED AIRSPEED	NUMBER: DGT-47

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23251 (CONT'D):

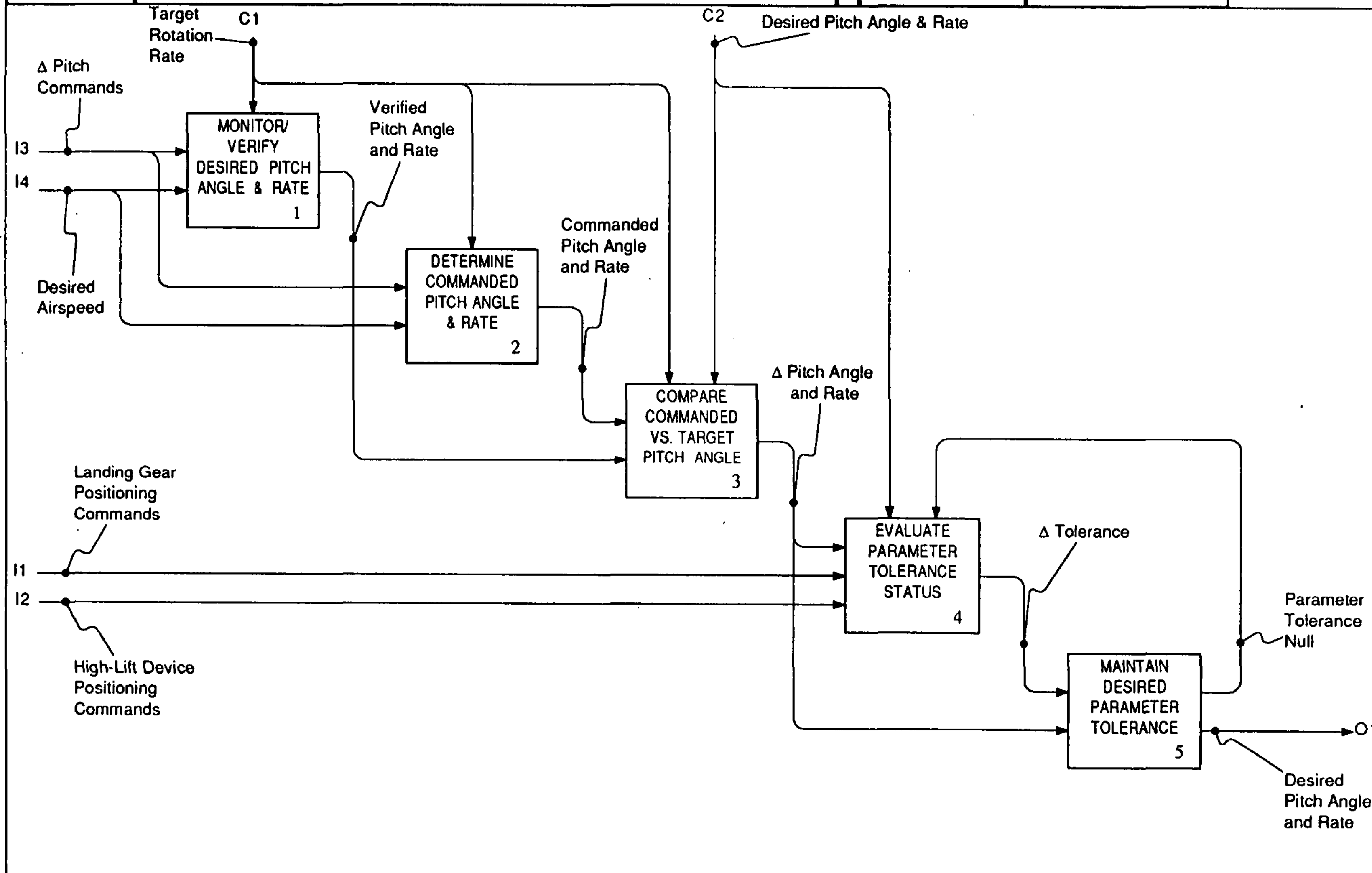
Δ TOLERANCE - If the Δ AIRSPEED PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

PARAMETER TOLERANCE NULL - The "nulling" of the airspeed change loop is accomplished by the airspeed change parameter tolerance being achieved through this iterative feedback/compensation activity.

DESIRED AIRSPEED - This is a desired or "target" airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

NODE: FACT / A23251 (CONT'D)	TITLE: GLOSSARY: MAINTAIN DESIRED AIRSPEED	NUMBER: DGT- 48

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER	DATE	CONTEXT: DG-30
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2325



NODE: FACT A23252	TITLE: MAINTAIN DESIRED PITCH ANGLE & RATE	NUMBER: DG-32

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/29/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23252:

Δ PITCH COMMANDS - This is a command to change pitch angle.

DESIRED AIRSPEED - This is a desired or "target" airspeed for this segment of the flight mission. A "target" airspeed may be critical to maintaining minimum airspeed for directional control, scheduling flap/slat retraction (or extension) activities, maintaining minimum ascent rates, etc. during takeoff.

TARGET ROTATION RATE - The desired rate of rotation (pitch attitude change) prior to aircraft lift-off.

HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the high-lift (flap/slat) devices.

LANDING GEAR & SPOILER POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear or drag devices.

VERIFIED PITCH ANGLE AND RATE - This is a verification of the aircraft's pitch angle and rate of pitch angle change (Δ Pitch) during the takeoff segment of the mission. Pitch angle and pitch rate values are verified in degrees and degrees change per second, respectively.

COMMANDED PITCH ANGLE AND RATE - The commanded pitch angle and rate of pitch angle change during this segment of the mission.

Δ PITCH ANGLE AND RATE - This is the difference between the commanded pitch angle and rate versus the target.

NODE: FACT / A23252	TITLE: GLOSSARY: MAINTAIN DESIRED PITCH ANGLE AND RATE	NUMBER: DGT-49

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23252 (CONT'D):

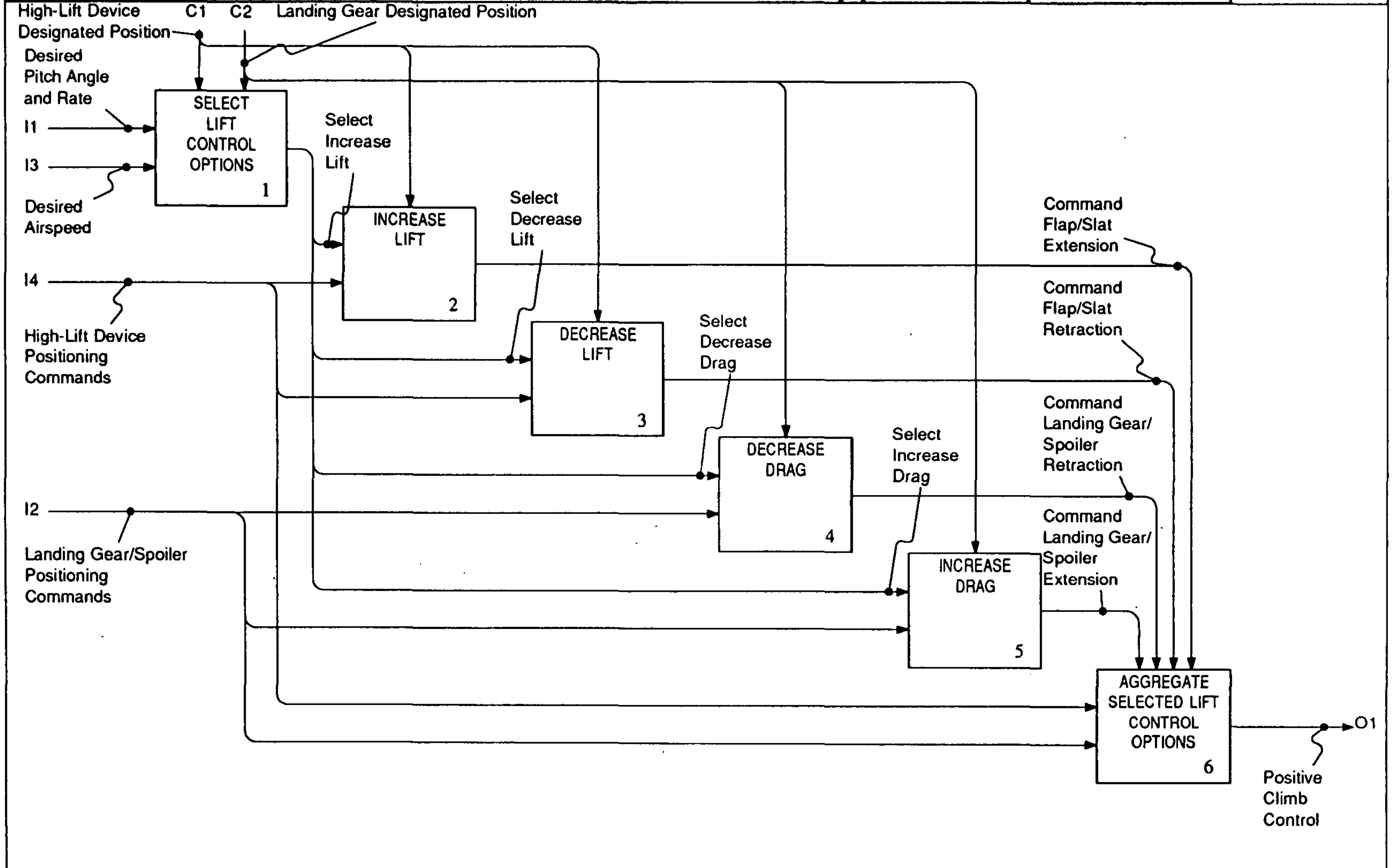
Δ TOLERANCE - If the Δ PITCH ANGLE AND RATE PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

PARAMETER TOLERANCE NULL - The "nulling" of the pitch angle and rate change loop.

DESIRED PITCH ANGLE AND RATE - The target pitch angle and rate of pitch angle change during this segment of the mission.

NODE: FACT /A23252 (CONT'D)	TITLE: GLOSSARY: MAINTAIN DESIRED PITCH ANGLE AND RATE	NUMBER: DGT-50

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER	DATE	CONTEXT: DG-30
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2325



NODE: FACT A23253	TITLE: PROVIDE AIRCRAFT LIFT CONTROL	NUMBER: DG-33

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A25253:

LANDING GEAR DESIGNATED POSITION - The designated position of the aircraft landing gear as specified by the operational sequence for this segment of the mission.

HIGH-LIFT DEVICE DESIGNATED POSITION - The designated position of the high-lift devices (flaps/slats) as specified by the operational sequence for this segment of the mission.

SELECT INCREASE LIFT - This is the lift increase selection that initiates the extension of the high-lift devices (flaps/slats).

SELECT DECREASE LIFT - This is the lift decrease selection that initiates the retraction of the high-lift devices (flaps/slats).

SELECT DECREASE DRAG - This is the drag decrease selection that initiates the retraction of the landing gear and spoilers.

SELECT INCREASE DRAG - This is the drag increase selection that initiates the extension of the landing gear and spoilers.

COMMAND FLAP/SLAT EXTENSION - This is the lift increase control activity that commands the extension of the high-lift devices (flaps/slats).

COMMAND FLAP/SLAT RETRACTION - This is the lift decrease control activity that commands the retraction of the high-lift devices (flaps/slats).

NODE: FACT / A23253	TITLE: GLOSSARY: PROVIDE AIRCRAFT LIFT CONTROL	NUMBER: DGT-51

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23253 (CONT'D):

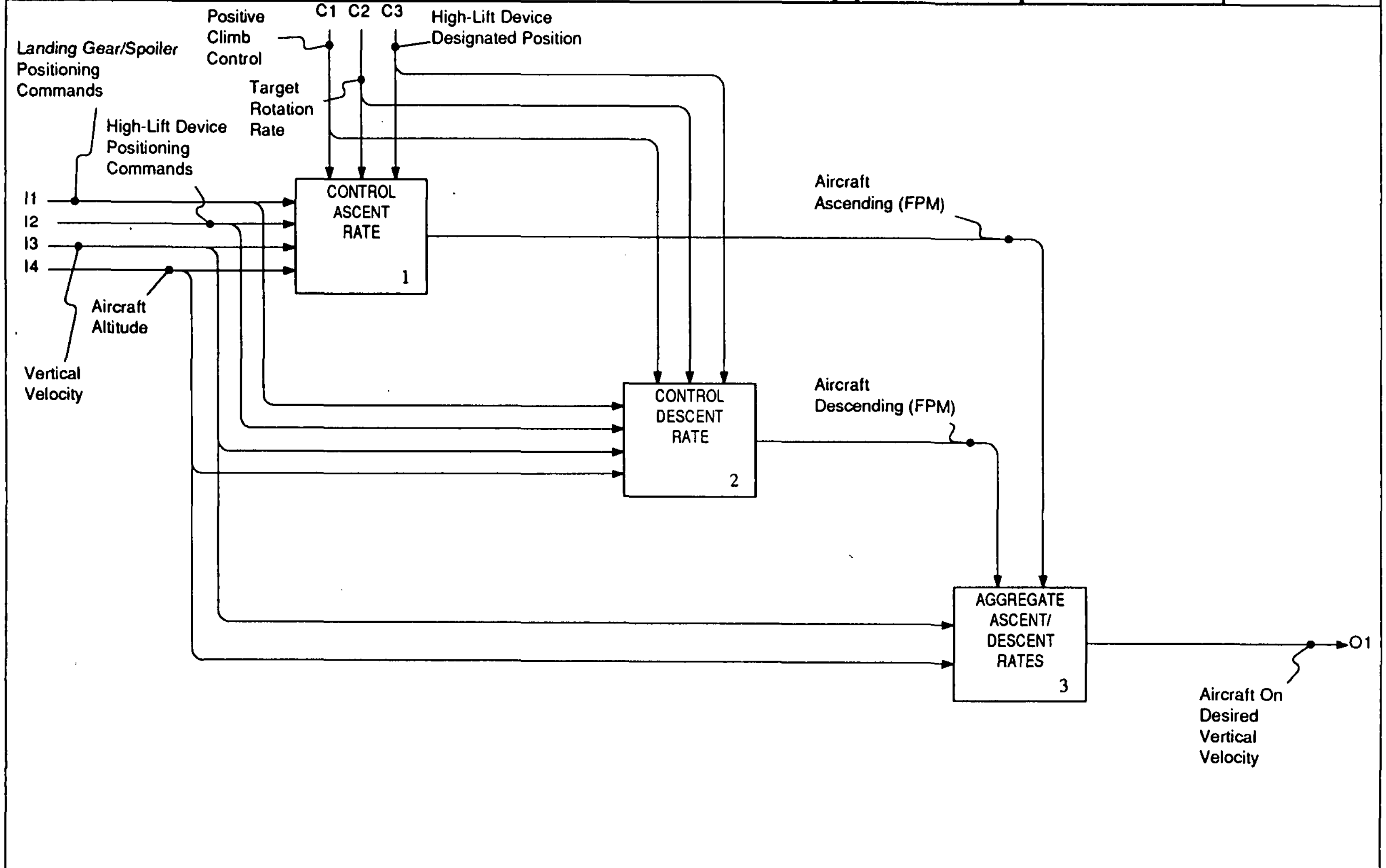
COMMAND LANDING GEAR/SPOILER RETRACTION - This is the drag decrease control activity that commands the retraction of the landing gear and spoilers.

COMMAND LANDING GEAR/SPOILER EXTENSION - This is the drag increase control activity that commands the extension of the landing gear and spoilers.

POSITIVE CLIMB CONTROL - The aircraft is now in a positive (up) rate of climb as required by the conditions existing after aircraft liftoff.

NODE: FACT /A23253 (CONT'D)	TITLE: GLOSSARY: PROVIDE AIRCRAFT LIFT CONTROL	NUMBER: DGT-52

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER DATE	CONTEXT: DG-30
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		A2325



NODE: FACT A23254	TITLE: CONTROL AIRCRAFT VERTICAL VELOCITY	NUMBER: DG-34

GLOSSARY - FACT A23254:

HIGH-LIFT DEVICE DESIGNATED POSITION - The designated position of the high-lift devices (flaps/slats) as specified by the operational sequence for this segment of the mission.

POSITIVE CLIMB CONTROL - The aircraft is now in a positive (up) rate of climb as required by the conditions existing after aircraft liftoff.

TARGET ROTATION RATE - The desired rate of rotation (pitch attitude change) prior to aircraft lift-off.

HIGH-LIFT DEVICE DESIGNATED POSITION - The designated position of the high-lift devices (flaps/slats) as specified by the operational sequence for this segment of the mission.

HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or *manually to the flight control system in order to affect the retraction or extension of the high-lift (flap/slat) devices.*

LANDING GEAR & SPOILER POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the landing gear or drag devices.

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23254 (CONT'D):

AIRCRAFT ALTITUDE - This is a measurement of the aircraft's altitude during the takeoff segment of the mission. Aircraft altitude may be available from either a barometric source (pressure altimeter) or above-ground-level (AGL) source from the radar altimeter.

VERTICAL VELOCITY - This is a measurement of the aircraft's ascent or descent rate during the takeoff segment of the mission. Aircraft vertical velocity is provided in feet-per-minute (FPM) change. Aircraft vertical velocity may be determined from a variety of sources: change in barometric altitude per minute, change in absolute altitude per minute, or a discrete measurement of actual vertical acceleration using precision accelerometers.

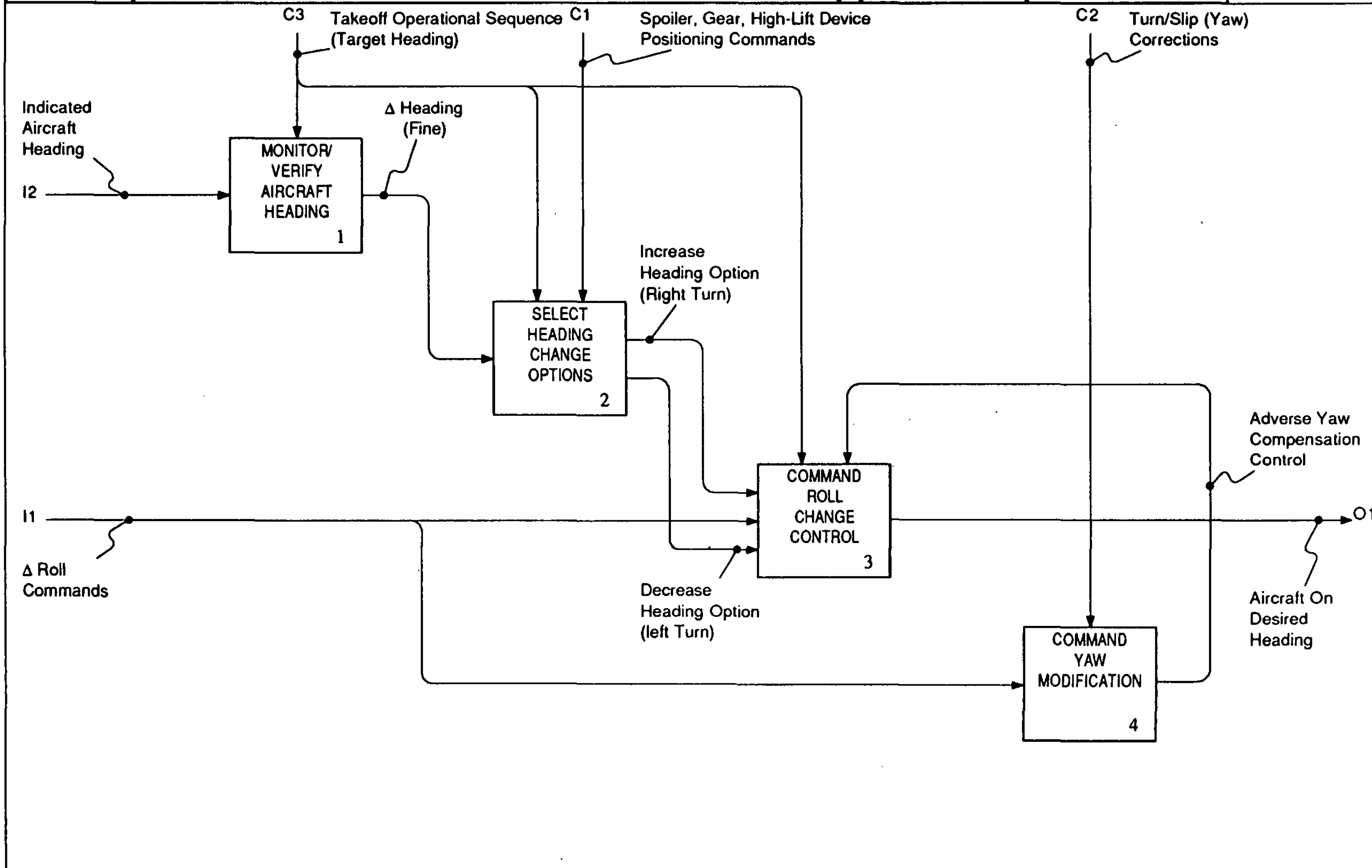
AIRCRAFT ASCENDING (FPM) - This is an indication that the aircraft is in an ascent (climb) at a measurement of feet-per-minute.

AIRCRAFT DESCENDING (FPM) - This is an indication that the aircraft is in a descent at a measurement of feet-per-minute.

AIRCRAFT ON DESIRED VERTICAL VELOCITY - After liftoff, the aircraft's ascent rate (vertical velocity) is controlled as required to attain a planned ascent rate, attain or maintain a desired altitude, or clear obstacles within the flight path.

NODE: FACT /A23254 (CONT'D)	TITLE: GLOSSARY: CONTROL AIRCRAFT VERTICAL VELOCITY	NUMBER: DGT-54

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-14 A232



NODE: FACT A2326	TITLE: CONTROL AIRCRAFT HEADING	NUMBER: DG-35

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT:

GLOSSARY - FACT A2326:

INDICATED AIRCRAFT HEADING - This a measurement of the aircraft's magnetic heading during the takeoff segment of the mission. Aircraft magnetic heading is provided in degrees (0-359) and increments of degrees for precision navigational computations.

Δ ROLL COMMANDS - This is a command to change roll angle.

TAKEOFF OPERATIONAL SEQUENCE - The operational sequence of events accomplished during the takeoff of the aircraft.

LANDING GEAR, SPOILER, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are *provided either automatically or manually to the flight control system in order to affect the retraction or extension of the* landing gear and/or lift or drag devices.

TURN/SLIP (YAW) CORRECTIONS - Compensating maneuvers to correct for unwanted yaw indications.

Δ HEADING (FINE) - The fine heading difference used to determine whether an increase or decrease heading selection is required.

INCREASE HEADING OPTION - This is the heading change option that allows for the command of a heading increase (or command roll right).

DECREASE HEADING OPTION - This is the heading change option that allows for the command of a heading decrease (or command roll left).

NODE: FACT / A2326	TITLE: GLOSSARY: CONTROL AIRCRAFT HEADING	NUMBER: DGT-55

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

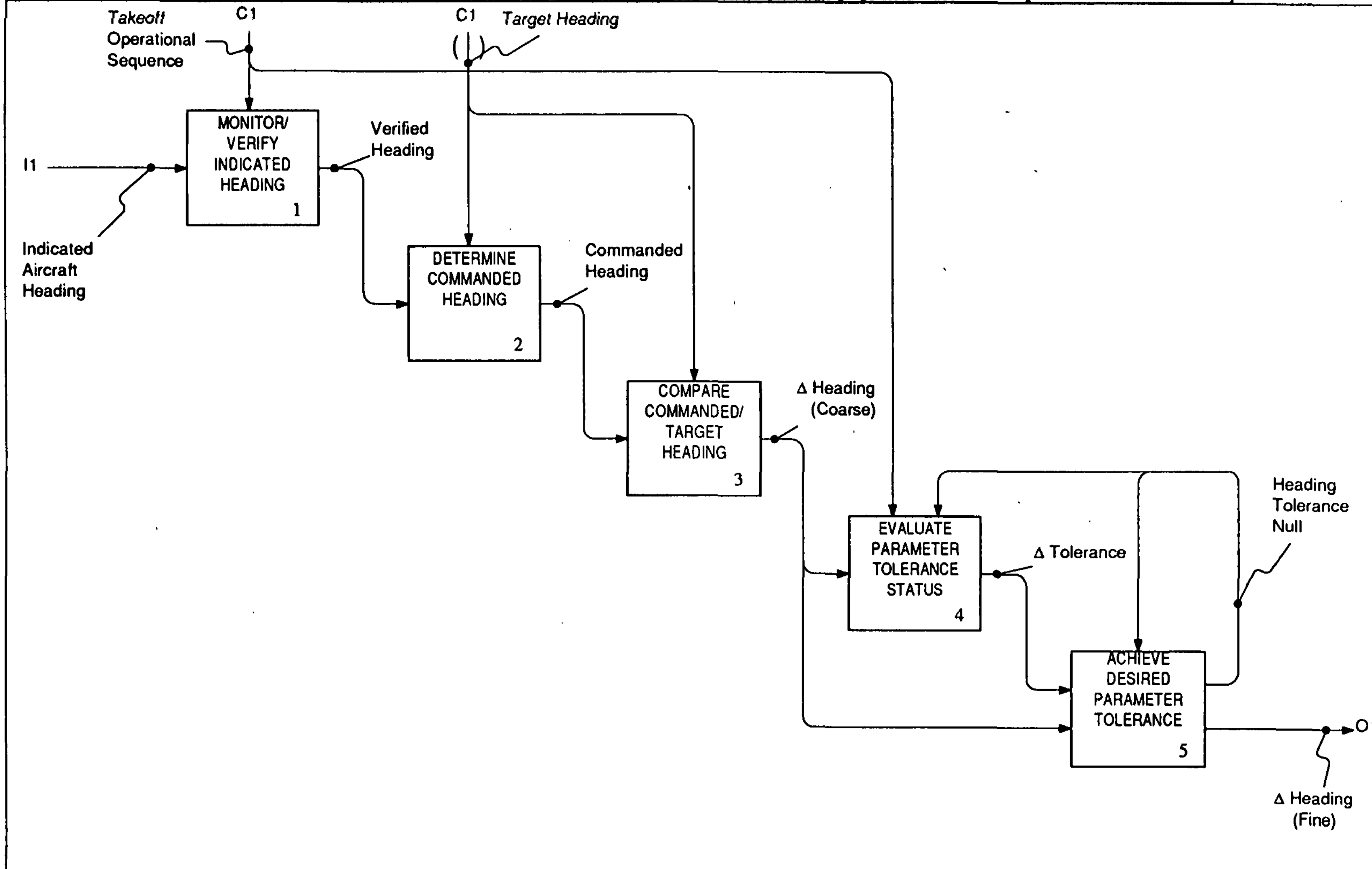
GLOSSARY - FACT A2326 (CONT'D):

ADVERSE YAW COMPENSATION CONTROL - Inputs to the "Command Roll Change Control" function that allows for a compensating yaw correction coupled to the affected left or right roll control channel.

AIRCRAFT ON DESIRED HEADING - After liftoff, the aircraft's magnetic heading is controlled as required to either maintain the takeoff heading or acquire the heading to a specified initial departure fix.

NODE: FACT / A2326 (CONT'D)	TITLE: GLOSSARY: MONITOR/VERIFY AIRCRAFT HEADING	NUMBER: DGT-56

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-35 A2326



NODE: FACT A23261	TITLE: MONITOR/ VERIFY AIRCRAFT HEADING	NUMBER: DG-36

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23261:

VERIFIED HEADING - This is a verification or confirmation of the heading of the aircraft at this time during this segment of the mission.

COMMANDED HEADING - This is the magnetic heading that the aircraft has been commanded to attain during this segment of the mission.

Δ HEADING (COARSE) - This is the coarse comparison between the commanded versus the desired heading.

Δ HEADING PARAMETER TOLERANCE - This is the allowable tolerance of the comparison between the commanded versus the desired heading.

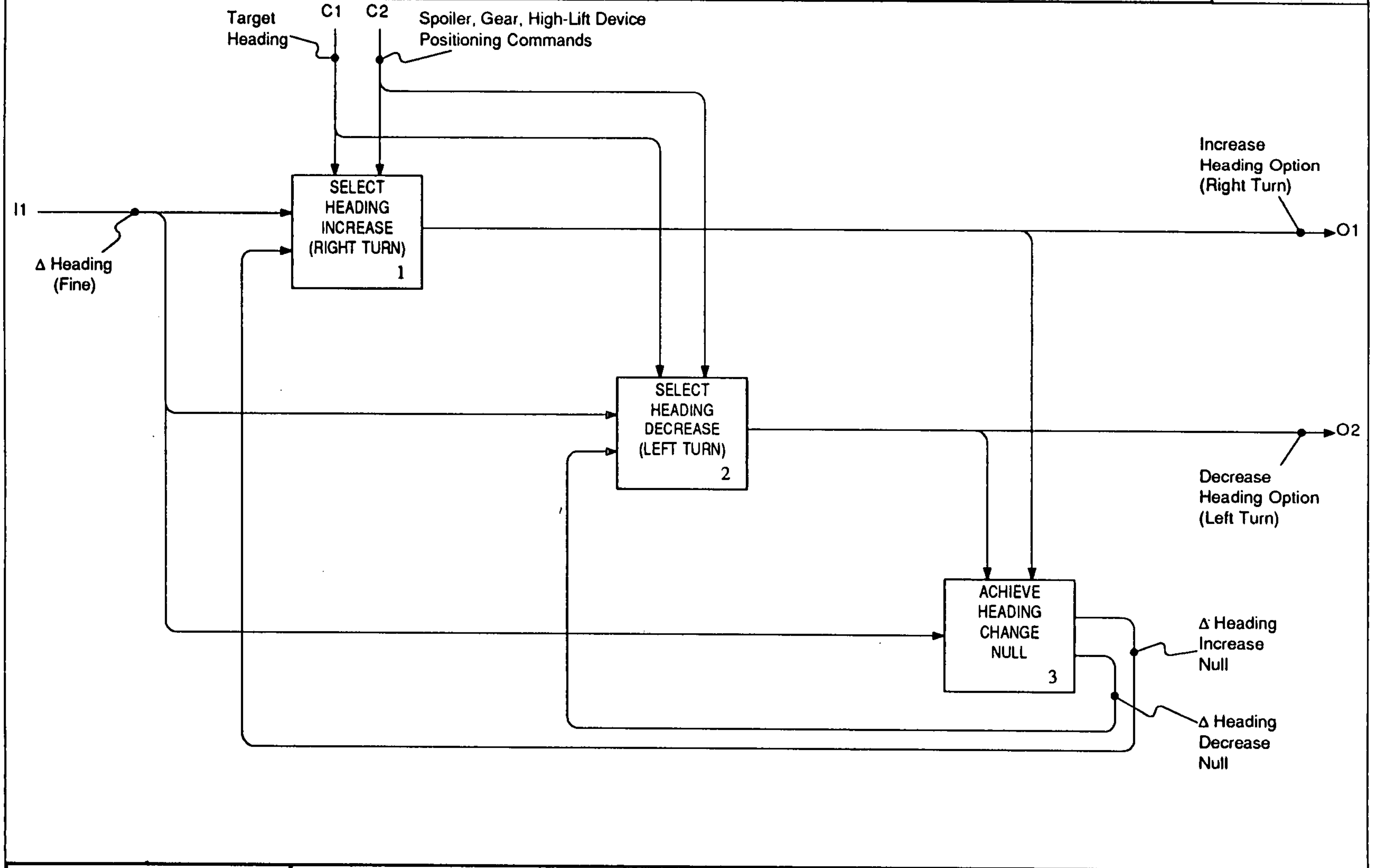
Δ TOLERANCE - If the Δ HEADING PARAMETER TOLERANCE exceeds the allowable value, the excess in expressed in this measurement.

HEADING TOLERANCE NULL - The "nulling" of the heading change loop.

Δ HEADING (FINE) - The fine changes being applied as a correction to control the aircraft heading.

NODE: FACT / A23261	TITLE: GLOSSARY: MONITOR/VERIFY AIRCRAFT HEADING	NUMBER: DGT-57

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER	DATE	CONTEXT: DG-35
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A2326



NODE: FACT A23262	TITLE: SELECT HEADING CHANGE OPTIONS	NUMBER: DG-37

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23262:

Δ HEADING (FINE) - The fine heading difference used to determine whether an increase or decrease heading selection is required.

TARGET HEADING - This is a"target" or desired heading for this segment of the flight mission. A "target" airspeed may be critical to maintaining runway heading, heading to initial departure fix, or heading required for obstacle avoidance, during takeoff.

SPOILER, GEAR, HIGH-LIFT DEVICE POSITIONING COMMANDS - These are the commands that are provided either automatically or manually to the flight control system in order to affect the retraction or extension of the lift or drag devices.

INCREASE HEADING OPTION (RIGHT TURN) - This is the heading change option that allows for the command of a heading increase (or command roll right).

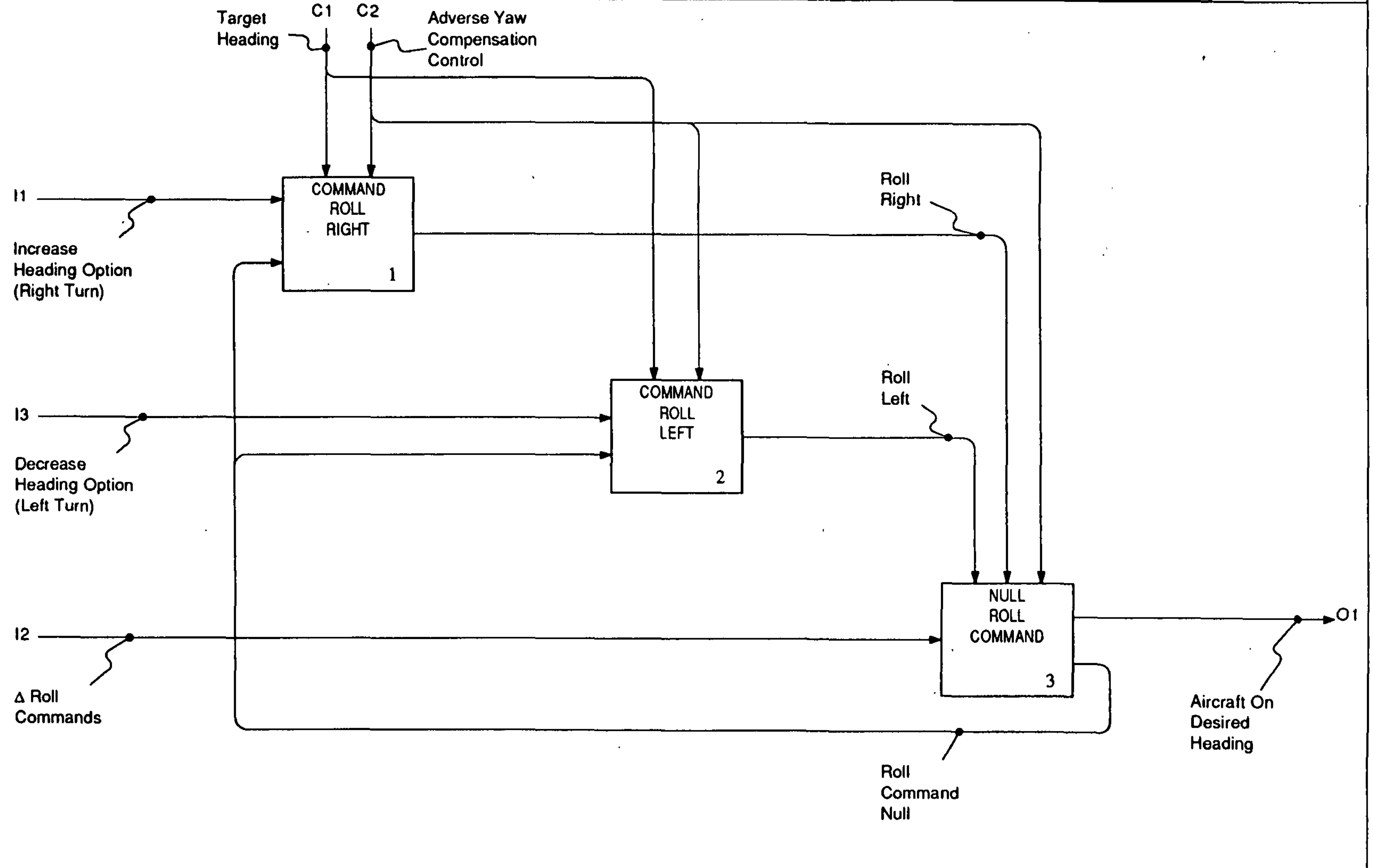
DECREASE HEADING OPTION (LEFT TURN) - This is the heading change option that allows for the command of a heading decrease (or command roll left).

Δ HEADING INCREASE NULL - The "nulling" of the increase heading change loop.

Δ HEADING DECREASE NULL - The "nulling" of the decrease heading change loop.

NODE: FACT / A23262	TITLE: GLOSSARY: SELECT HEADING CHANGE OPTIONS	NUMBER: DGT-58

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER DATE	CONTEXT: DG-35
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		A2326



NODE: FACT A23263	TITLE: COMMAND ROLL CHANGE CONTROL	NUMBER: DG-38

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A23263:

TARGET HEADING - This is a"target" or desired heading for this segment of the flight mission. A "target" airspeed may be critical to maintaining runway heading, heading to initial departure fix, or heading required for obstacle avoidance.

ADVERSE YAW COMPENSATION CONTROL - Inputs to the "Command Roll Change Control" function that allows for a compensating yaw correction coupled to the affected left or right roll control channel.

INCREASE HEADING OPTION (RIGHT TURN) - This is the heading change option that allows for the command of a heading increase (or command roll right).

DECREASE HEADING OPTION (LEFT TURN) - This is the heading change option that allows for the command of a heading decrease (or command roll left).

Δ ROLL COMMANDS - This is a command to change roll angle.

ROLL COMMAND NULL - The "nulling" of the roll command loops.

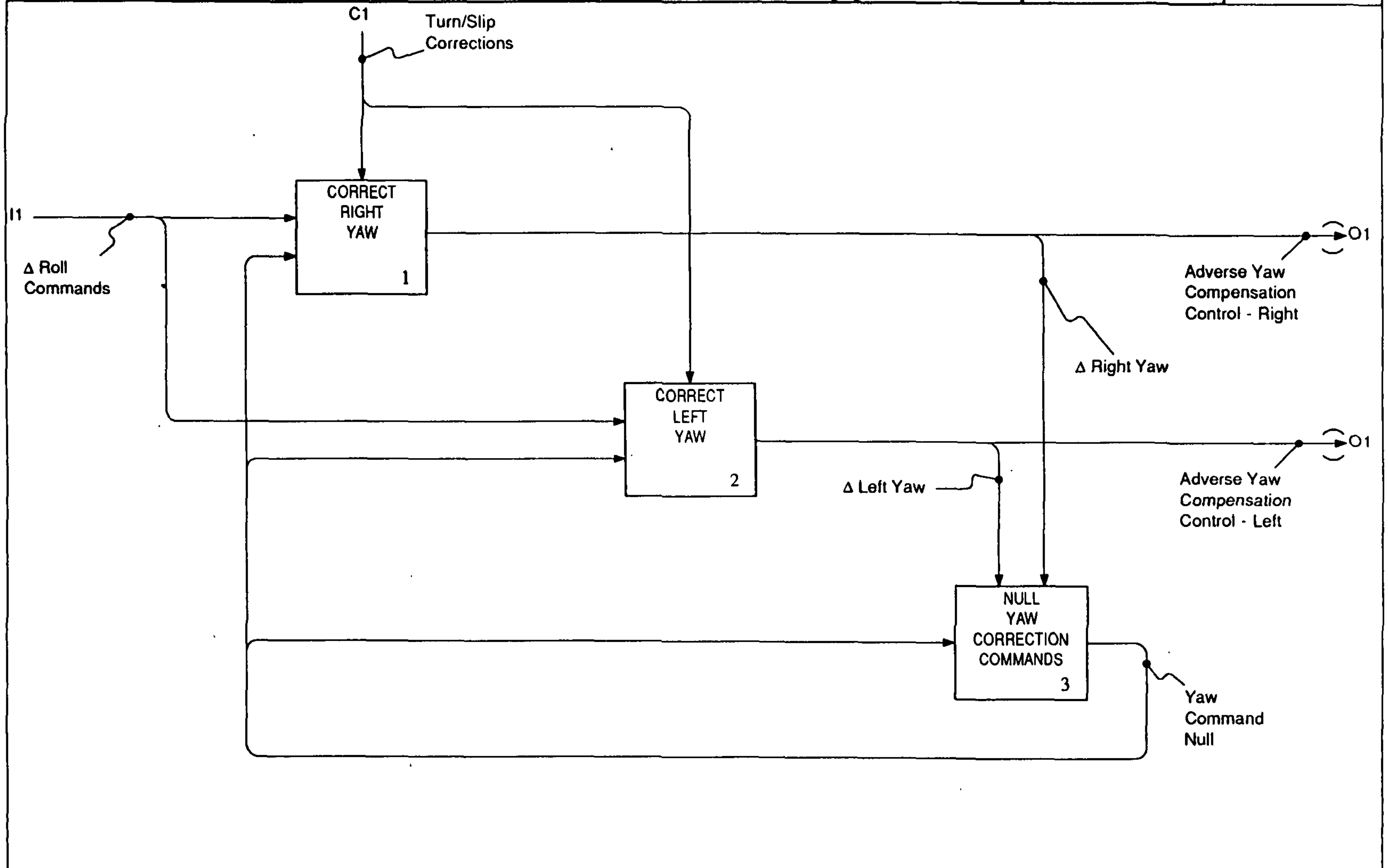
ROLL RIGHT - This is the roll change command that initiates a heading increase.

ROLL LEFT - This is the roll change command that initiates a heading decrease.

AIRCRAFT ON DESIRED HEADING - After liftoff, the aircraft's magnetic heading is controlled as required to either maintain the takeoff heading or acquire the heading to a specified initial departure fix.

NODE: FACT / A23263	TITLE: GLOSSARY: COMMAND ROLL CHANGE CONTROL	NUMBER: DGT-59

USED AT:	AUTHOR: R. T. Goins PROJECT: *FACT* NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER DATE	CONTEXT: DG-35
			X	*DRAFT*		
				RECOMMENDED		
				PUBLICATION		A2326



NODE: FACT A23264	TITLE: COMMAND YAW MODIFICATION	NUMBER: DG-39

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A23264:

TURN/SLIP CORRECTIONS - Requirements to correct for yaw conditions.

Δ LEFT YAW - Left yaw angle and rate of change of yaw angle as it relates the left turning and rolling of the aircraft during the takeoff segment of the mission. Left yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

Δ RIGHT YAW - Right yaw angle and rate of change of yaw angle as it relates the right turning and rolling of the aircraft during the takeoff segment of the mission. Right yaw angle and yaw rate values are provided in degrees and degrees per second, respectively.

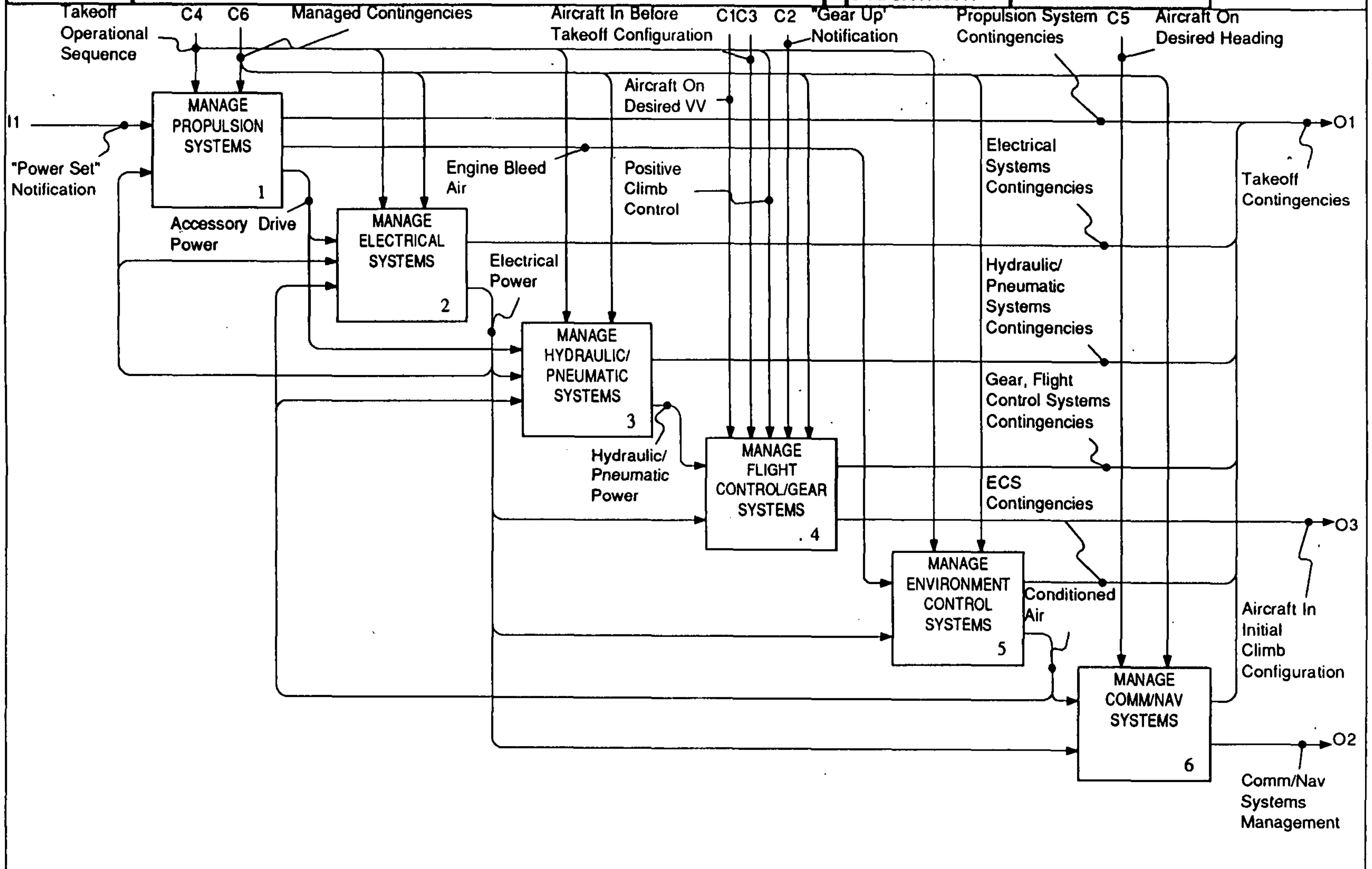
ADVERSE YAW COMPENSATION CONTROL - LEFT - Outputs from the "Correct Left Yaw" function that allows for a compensating yaw correction coupled to the affected roll control channel.

ADVERSE YAW COMPENSATION CONTROL - RIGHT - Outputs from the "Correct Right Yaw" function that allows for a compensating yaw correction coupled to the affected roll control channel.

YAW COMMAND NULL - The "nulling" of the yaw correction command loop.

NODE: FACT / A23264	TITLE: GLOSSARY: COMMAND YAW MODIFICATION	NUMBER: DGT-60

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:		WORKING	READER	DATE	CONTEXT: DG-12
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			A233



NODE: FACT A233	TITLE: MANAGE AIRCRAFT SYSTEMS	NUMBER: DG-40

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A233:

TAKEOFF OPERATIONAL SEQUENCE - The operational sequence of events accomplished during the takeoff of the aircraft.

MANAGED CONTINGENCIES - The status of the aircraft, crew and payload subsequent to the actions taken in the "Manage Contingencies" function.

AIRCRAFT IN BEFORE TAKEOFF CONFIGURATION - This is an aircraft condition state. The aircraft engines are started, the systems are activated, and the necessary operational sequence of events have been accomplished that place the aircraft in a before takeoff configuration.

"GEAR UP" NOTIFICATION - This notifies the crew that the aircraft has met the conditions required to retract the landing gear.

AIRCRAFT ON DESIRED HEADING - After liftoff, the aircraft's magnetic heading is controlled as required to either maintain the takeoff heading or acquire the heading to a specified initial departure fix.

"POWER SET" NOTIFICATION - This notifies the flight deck crew that the takeoff power setting has been accomplished.

AIRCRAFT ON DESIRED VV - After liftoff, the aircraft's ascent rate (vertical velocity) is controlled as required to attain a planned ascent rate, attain or maintain a desired altitude, or clear obstacles within the flight path.

POSITIVE CLIMB CONTROL - The aircraft is now in a positive (up) rate of climb as required by the conditions existing after aircraft liftoff.

NODE: FACT / A233	TITLE: GLOSSARY: MANAGE AIRCRAFT SYSTEMS	NUMBER: DGT-61

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A233 (CONT'D):

TAKEOFF CONTINGENCIES - These are the unexpected events that occur during the aircraft takeoff segment of the mission. Typical takeoff contingencies may be: engine failure, asymmetrical flap/slat retraction,etc.

AIRCRAFT IN INITIAL CLIMB CONFIGURATION - This is an aircraft condition state. The aircraft has lifted off the runway. The gear, flaps/slats have been retracted, and the aircraft is on initial climb speed schedule enroute to the initial departure fix.

COMM/NAV SYSTEMS MANAGEMENT - Management of the aircraft communications/navigation system as required to affect the necessary communications during the takeoff segment of the mission.

ACCESSORY DRIVE POWER - Power to drive the engine-driven accessories. Engine-driven accessories include the generator/alternator drives and hydraulic pump drives.

ENGINE BLEED AIR - Multiple-stage generated engine bleed air that is used to feed the aircraft environmental control system (ECS).

ELECTRICAL POWER - AC and DC power that is generated within the aircraft electrical power systems

HYDRAULIC/PNEUMATIC POWER - Hydraulic and pneumatic (air) power used to drive hydraulically-driven flight control power systems. Pneumatic power serves as a back-up power source.

CONDITIONED AIR - Air used to provide crew and passenger cabin pressurization and heating/cooling as required.

NODE: FACT / A233 (CONT'D)	TITLE: GLOSSARY: MANAGE AIRCRAFT SYSTEMS	NUMBER: DGT- 62

GLOSSARY - FACT A233 (CONT'D):

PROPULSION SYSTEMS CONTINGENCIES - These are the unexpected events that affect the operation and control of the aircraft propulsion systems during this segment of the mission. Includes contingencies associated with the aircraft engine and the fuel/fuel control system.

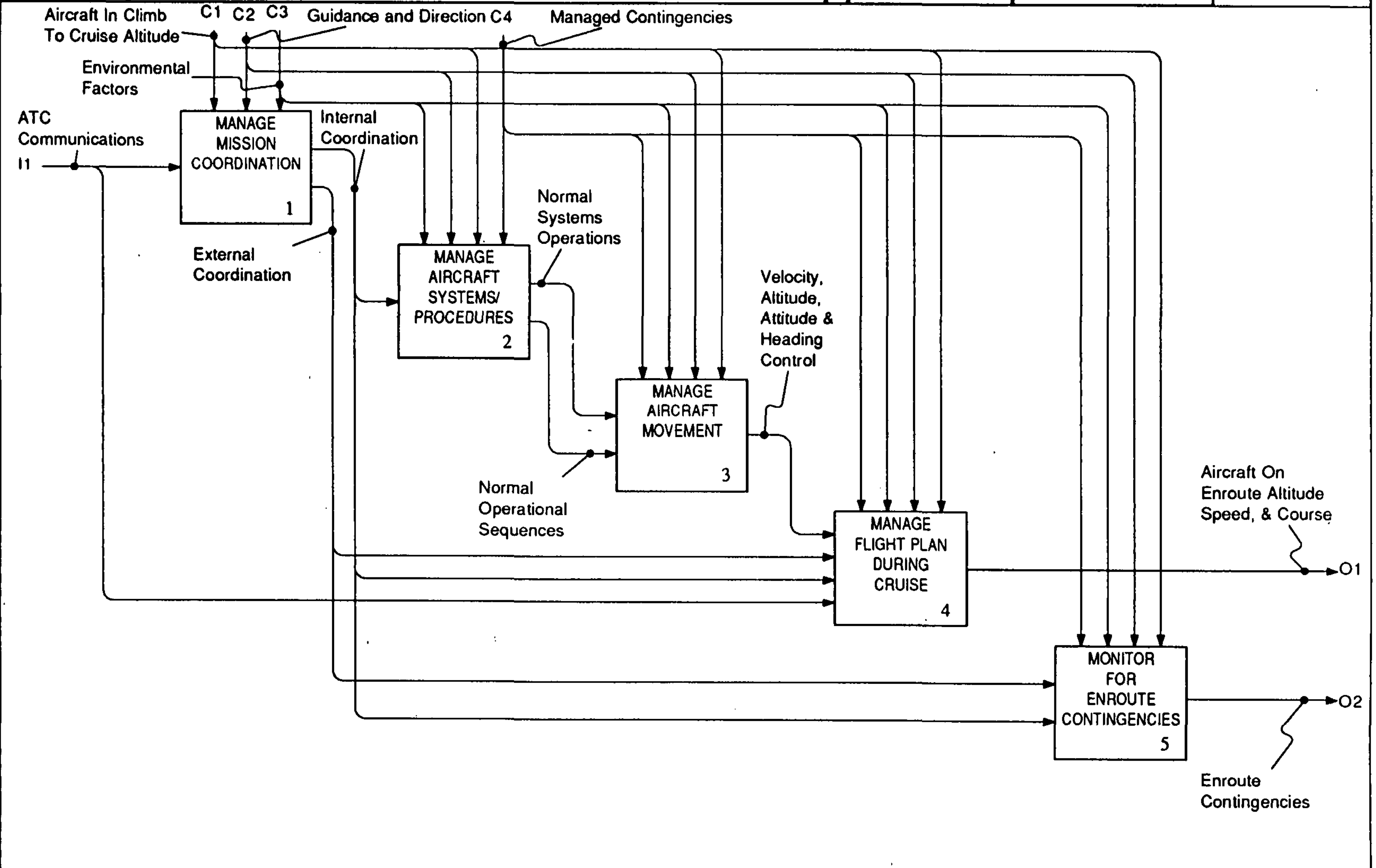
ELECTRICAL SYSTEMS CONTINGENCIES - These are the unexpected events that affect the operation and control of the aircraft electrical systems during this segment of the mission. Includes contingencies associated with the aircraft generator/alternators and the alternate/emergency electrical power sources.

HYDRAULIC/PNEUMATIC SYSTEMS CONTINGENCIES - These are the unexpected events that affect the operation and control of the aircraft hydraulic/pneumatic systems during this segment of the mission.

GEAR, FLIGHT CONTROL SYSTEMS CONTINGENCIES - These are the unexpected events that affect the operation and control of the aircraft landing gear and flight control systems during this segment of the mission. Includes contingencies associated with the aircraft high-lift and drag devices (flaps/slats, spoilers).

ECS CONTINGENCIES - These are the unexpected events that affect the operation and control of the aircraft environmental control systems during this segment of the mission. Includes contingencies associated with the aircraft cabin pressurization and temperature/humidity control systems.

USED AT:	AUTHOR: R. T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/23/90 REV:	WORKING X DRAFT RECOMMENDED PUBLICATION	READER DATE	CONTEXT: DG-02 A0



NODE: FACT A3	TITLE: PERFORM ENROUTE CRUISE ACTIVITIES	NUMBER: DG-41

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER DATE	CONTEXT:
			X	DRAFT		
				RECOMMENDED		
				PUBLICATION		

GLOSSARY - FACT A3:

AIRCRAFT IN INITIAL CLIMB CONFIGURATION - This is an aircraft condition state. The aircraft has lifted off the runway. The gear, flaps/slats have been retracted, and the aircraft is on initial climb speed schedule enroute to the initial departure fix.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, precipitation, visibility, runway surface conditions, abnormal meteorlogical conditions.

GUIDANCE AND DIRECTION - Guidance and direction provided through the use of FARs, Advisory Circulars, NOTAMs, the various airline company regulations and requirements, and information provided by the ATC controller. Includes Air Route Traffic Control Centers (ARTCC), available Navaids, operational sequences, the designated mission flight plan, and local operating procedures.

ATC COMMUNICATIONS - Communications received, or transmitted via the ARTCC network.

INTERNAL COORDINATION - Activties coordinated within the aircraft cockpit and/or cabin.

EXTERNAL COORDINATION - Activities coordinated outside of the cockpit and/or cabin environments. This coordination includes those associated within either the ground crew or the ATC controlling functions.

NORMAL SYSTEMS OPERATIONS - Operation of the aircraft systems under normal conditions.

NORMAL OPERATIONAL SEQUENCES - Operational sequences that occur under normal operating conditions.

NODE: FACT / A3	TITLE: GLOSSARY: PERFORM ENROUTE CRUISE ACTIVITIES	NUMBER: DGT- 64

USED AT:	AUTHOR: R.T. Goins PROJECT: FACT NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 9/30/90 REV:		WORKING	READER	DATE	CONTEXT:
			X	DRAFT			
				RECOMMENDED			
				PUBLICATION			

GLOSSARY - FACT A3 (CONT'D):

VELOCITY, ALTITUDE, & HEADING CONTROL - Maintaining control of the aircraft's critical flight parameters to ensure safe and efficient operation of the aircraft during the cruise phase of the mission.

AIRCRAFT ON ENROUTE ALTITUDE, SPEED, & COURSE - Managing the mission flight plan. This ensures that the aircraft maintains its planned course of flight and estimated arrival times at selected waypoints. Includes fuel management and severe weather avoidance as required.

ENROUTE CONTINGENCIES - These are the unexpected events that occur during the enroute/cruise phase of the mission.

NODE: FACT / A3 (CONT'D)	TITLE: GLOSSARY: PERFORM ENROUTE CRUISE ACTIVITIES	NUMBER: DGT-65

APPENDIX I

DESCRIPTION OF A FUNCTIONAL RELATIONSHIPS DATABASE

During the design integration phase of the function allocation methodology, the allocator constructs the pairwise relationships among all possible pairs of "H" and "H/A" tasks. This step and subsequent viewing of the relationship network and cluster analyses on pair relationships requires a database that is derived from, but separated from, the functional requirements database. The table below lists the fields for this relationships database.

TABLE I-I — FUNCTIONAL RELATIONSHIPS DATABASE

Database Section	Column Name	Data Type
Function X	Name/number	Character
Function Y	Name/number	Character
Comparison ratings	Shared goals	Numeric
	Shared subsystems	Numeric
	Shared information	Numeric
	Temporal co-occurrence	Numeric
	Resource competition	Numeric
	Composite ratings	Numeric
	User-defined	Numeric
	User-defined	Logical

APPENDIX J

DESCRIPTION OF PROGRAM DATABASE

This Appendix identifies a set of database fields that contain information needed to conduct human-system function allocation in commercial aircraft design. Character, numeric and logical fields can be produced in any popular database package for microcomputers (e.g., *4th Dimension, Excel, dBase, Works*, etc.) or in larger mainframe packages (e.g., *Ingres*). Fields that contain text blocks or graphics are not as easily represented in some of the existing tools, particularly those hosted on character-based computer systems.

Depending on the size limitations of the database package used, all of the fields that can be represented in a given package might be included in a single file. However, for an *entire* functional description of an airliner mission, one will run into size problems with PC-based systems running under DOS due to the 640K limitation on memory. Under these circumstances, multiple databases will be required. This requirement poses no particular problem, however, as long as a set of identifier fields are copied from one database to another to permit cross-sorts, relational referencing, copying, etc.

In constructing the database specification, we made the following assumptions:

1. The Function Allocator is following the allocation methodology described in Rouse and Cody (ref. 16).

2. The Function Allocator's necessary and sufficient information requirements derive from this methodology. We reviewed each step of the methodology to define its inputs and outputs. These inputs, outputs, and the allocator's task associated with them suggested the database structure, fields, and operations.

3. According to Rouse's methodology, the allocation policy emerges over three major cycles or iterations. Each cycle includes allocation followed by design (to determine what displays, controls, and procedures the human's tasks will involve) and evaluation (to verify that the human can perform the tasks so designed). The first cycle results in an initial or coarse allocation, task design ,and evaluation. In the second cycle, opportunities for integrating related functions and separating functions that conflict for human resources are treated. In the third stage, static and dynamic allocation policies are determined.

   Hence, the function allocator "fills in" the database as he or she proceeds. The necessary and sufficient information for executing Rouse's methodology emerges as design progresses. The information cannot all be obtained "in advance" of allocation. Therefore, the database design includes information fields that can (must) be filled in to begin the

methodology, but also anticipates fields that the allocator generates in performing the methodology.

4. As much as possible, we used the mission decomposition and database definition materials already provided by Douglas Aircraft Company under this project.

TABLE J-I — PROGRAM DATABASE

Database Section	Column Name	Data Type
Mission Timeline:		
Mission Identification	Type	Character
	Period	Character
	Phase	Character
	Segment name	Character
System State Vector:		
Vehicle state	Elapsed time	Real
	X-pos	Real
	Y-pos	Real
	Altitude	Real
	Ground velocity	Real
	Flight path angle	Real
	Heading	Real
Object relationships	INS waypoint selected	Integer
	Waypoint range	Real
	Waypoint bearing	Real
	TACAN range	Real
	TACAN bearing	Real
	ADF bearing	Real
	Other a/c range	Real
	Other a/c bearing	Real
	Other a/c elevation	Real
Subsystem State Vectors:		
Propulsion	Engine ignition	Integer
	Engine start fuel	Integer
	Engine mode	Integer
	Fuel transfer mode	Integer
Secondary FCS	Flaps leading edge	Integer
	Flaps trailing edge	Integer
Automatic FCS	Auto-throttle mode	Integer
	Auto-throttle status	Integer
	Auto-throttle setting	Integer
	Altitude-hold mode	Integer
	Auto pilot mode	Integer

TABLE J-I — (Continued)

Database Section	Column Name	Data Type
Flight planning system Aircraft guidance system Flight progress monitor Performance mgmt system	Status, modes and settings per system	Integers
Landing gear	Nose gear state	Integer
	Center gear state	Integer
	Main gear state	Integer
	Nose wheel steering	Integer
Brakes	Auto-brake mode	Integer
	Anti-skid mode	Integer
Navigation	INS mode	Integer
	DME status	Integer
	ADF status	Integer
	TACAN channel	Integer
	Radio altimeter set	Real
Instrumentation	Traffic alert/avoid	Integer
	Ground warning status	Integer
Electrical Lighting Hydraulic Air system Fire detection Warning/alerting	Status, modes and settings per system	Integer
Communications	Transmitter selected	Integer
	Channel	Integer
	Frequency	Real
Ice & rain protection	De-ice system mode	Integer
	Weather radar mode	Integer
	Weather radar status	Integer
	Weather radar range	Integer
	Weather radar gain	Integer
	Weather radar angle	Integer

TABLE J-I — (Continued)

Database Section	Column Name	Data Type
Functional Requirements:		
Function identification	Number	Character
	Indentation Level	Integer
	Function Name	Character
	Category	Character
	Function type	Character
Function attributes	Duration	Real
	Duration variance	Real
	Earliest start	Real
	Latest start	Real
	Goal (parent function)	Integer
	Predecessor function(s)	Integer
	Trigger condition(s)	Character
	Ending condition(s)	Character
	Uses subsystem(s)	Integer
	Criticality to mission	Integer
Information requirements	Variable name(s)	Character
	Required accuracy	Character
	No. samples required	Character
Allocation	Designated performer(s)	Character
Performance and Cost Goals		
Desired performance	Duration	Real
	Duration variance	Real
	Error likelihood	Real
Firm Constraints	Space	Numeric
	Weight	Numeric
	Location	Text/graphic
	Signal access	Text/graphic
	Use of existing a/c syst	Text
	Use of existing equipment	Text
	Flexibility to upgrade	Text
	Technology availability	Text

TABLE J-I — (Continued)

Database Section	Column Name	Data Type
Production cost goals	Fabrication	Numeric
	Assembly	Numeric
	Testing	Numeric
Operational support goals	Manpower requirements	Text/numeric
	Personnel requirements	Text/numeric
	Training requirements	Text/numeric
	Logistics	Text/numeric
"Task Window:"		
Description	Text description	Text
Display	Preferred location	Integer
	Medium, hardware requirements	Text
	Type	Character
	Picture	Graphic
	Software requirements	Text
Control/Input	Preferred location	Character
	Medium, hardware requirements	Character
	Type	Character
	Picture	Graphic
	Software requirements	
Procedure	Description	Text
	Training requirements	Text
Human Resource Requirements	Input (visual/auditory)	Character
	Processing (verbal/spatial)	Character
	Output (manual/speech)	Character
Model	Description	Text
	Equation or software	Text
Performance predictions	Expected duration	Real
	Expected duration variance	Real
	Expected error	Real
Evaluation Data:		
Actual performance	Duration	Real
	Duration variance	Real
	Error likelihood	Real

TABLE J-I — (Continued)

Database Section	Column Name	Data Type
Constraint satisfaction	Space	Numeric
	Weight	Numeric
	Location	Text/graphic
	Signal access	Text/graphic
	Use of existing a/c syst	Text
	Use of existing equipment	Text
	Flexibility to upgrade	Text
	Technology availability	Text
Actual production cost	Fabrication	Text/Numeric
	Assembly	Text/Numeric
	Testing	Text/Numeric
Actual operational support cost	Manpower requirements	Text/Numeric
	Personnel requirements	Text/Numeric
	Training requirements	Text/Numeric
	Logistics	Text/Numeric

APPENDIX K

DESCRIPTION OF A FUNCTION DICTIONARY

This Appendix contains descritpion of 128 commercial airline system functions. These functions were derived from operational procedures manuals for an advanced commercial transport, previous function decompositions, and function definitions developed by Douglas Aircraft.

The functions are divided into four categories as defined by Douglas Aircraft Company:

- Manage Aircraft Movement
- Manage Flight Plan
- Manage Aircraft Systems and Procedures
- Manage Flight Coordination

In keeping with the definition of a function, each entry represents a goal-directed activity that is required to meet some mission or system goal or accomplish some higher-level function. As can be seen from the list, the 128 functions represent different level in a hierarchical decomposition. Functions whose values are described as "summary procedures," if used in an actual function timeline, would have to be decomposed into several more granular subfunctions from the list.

For example, function #44 "Execute Missed Approach" is a summary function that includes subfunctions drawn from the flight control, subsystems management and communication categories. In building a function timeline, the allocator would list the "Missed Approach" function as a parent and all appropriate subfunctions as children. Each child function may, in turn, require further decomposition to arrive at allocatable primitive functions for which tasks can be constructed.

Each entry in this appendix is identified by a unique number (used for identification purposes in function timelines and the relationship databases), a function verb and a function object. Where appropriate, the value that the object can assume or its units of measurement are provided.

The concept for using this database is straightforward. We assumed that in constructing a function timeline, the function allocator could be supported with a list functions whose meanings were standardized. While these 128 functions are far from exhaustivel of those that are required in commerical aviation, they do illustrate the nature of this supporting database.

TABLE K-I — FUNCTION DICTIONARY

Function Category	No.	Verb	Object	Units
Manage Aircraft Movement	1	adjust	pitch	degrees
	2	adjust	roll	degrees
	3	adjust	yaw	degrees
	4	adjust	thrust	value
	5	select	pitch trim	value
	6	select	roll trim	value
	7	select	flaps-leading edge	up down
	8	select	flaps-trailing edge	0, 1, 5, 10, 20, 30
	9	select	speedbrakes	armed, up, flight detent down
	10	select	spoilers	in, mid, out
	11	adjust	ground brakes	value
	12	adjust	nose wheel steering	value
	13	select	airspeed	kts
	14	monitor	airspeed	kts
	15	hold	airspeed	kts
	16	change	airspeed	kts
	17	select	altitude	feet
	18	monitor	altitude	feet
	19	hold	altitude	feet
	20	change	altitude	feet
	21	select	heading	degrees
	22	monitor	heading	degrees
	23	hold	heading	degrees
	24	change	heading	degrees
	25	select	flight path angle	degrees
	26	monitor	flight path angle	degrees
	27	hold	flight path angle	degrees
	28	change	flight path angle	degrees
	29	execute	straight & level	maneuver
	30	execute	climb	maneuver
	31	execute	constant angle descent	maneuver
	32	execute	decel at constant angle	maneuver
	33	execute	dive	maneuver
	34	execute	flare	maneuver
	35	execute	level turn	maneuver
	36	execute	pitch-over	maneuver
	37	execute	pitch-up	maneuver
	38	execute	steep turn	maneuver
	39	execute	instrument approach	summary procedure
	40	execute	instrument departure	summary procedure
	41	execute	instrument hold	summary procedure
	42	execute	instrument land	summary procedure
	43	execute	instrument takeoff	summary procedure
	44	execute	missed approach	summary procedure
	45	execute	take-off abort	summary procedure
	46	execute	stall recovery	summary procedure

TABLE K-I — (Continued)

Function Category	No.	Verb	Object	Units
	47	execute	visual take-off.	summary procedure
Manage Flight Plan	48	intercept	ADF bearing	degrees
	49	track	ADF bearing	degrees
	50	intercept	course	degrees
	51	track	course	degrees
	52	intercept	DME arc	nm
	53	track	DME arc	nm
	54	intercept	ILS glideslope	dots
	55	track	ILS glideslope	dots
	56	intercept	ILS localizer	dots
	57	track	ILS localizer	dots
	58	intercept	TACAN radial	integer
	59	track	TACAN radial	integer
	60	intercept	VOR radial	integer
	61	track	VOR radial	integer
	62	select	ILS freq	Hz
	63	select	course	integer
	64	select	waypoint	integer
	65	select	INS data	pos, tk/gs, hdg/da, wypt.
	66	select	INS mode	off, stby, align, nav, att
	67	select	ADF freq	Hz
	68	select	ADF status	on, off
	69	select	DME arc	integer
	70	select	DME freq	Hz
	71	select	nav steering mode	INS, hdg, VOR, ILS, land
	72	select	VOR freq	Hz
	73	prepare	land	summary procedure
	74	prepare	emergency land	summary procedure
	75	prepare	take-off	summary procedure
Manage Aircraft Systems & Procedures	76	select	landing gear-center	up, down
	77	select	landing gear-main	up, down
	78	select	landing gear-nose	up, down
	79	select	nose wheel steering	on, off
	80	select	anti-skid	on, off
	81	select	auto-brake mode	disarm, min, med, max
	82	select	auto-brake status	on, off
	83	select	altitude-hold	on, off
	84	select	auto-throttle mode	turb, vert/s, ias
	85	select	auto-throttle speed	kts
	86	select	auto-throttle status	on, off
	87	select	auto-pilot data	INS, air, data...
	88	select	auto-pilot status	on, off
	89	select	fuel transfer	off, automatic
	90	select	jettison fuel	on, off

TABLE K-I — (Continued)

Function Category	No.	Verb	Object	Units
	91	select	engine start fuel	idle, rich, cutoff
	92	select	engine ignition	on, off
	93	select	engine mode	on, shutdown
	94	select	engine fire extinguish	off, arm, discharge
	95	select	transmitter	HF, VHF, UHF
	96	select	transmitter freq	Hz
	97	select	transmitter status	transmit, receive
	98	select	intercom	on, off
	99	select	flight recorder status	on, off
	100	select	weather radar status	on, off
	101	select	weather radar mode	stby, norm, cont, map
	102	select	weather radar range	30, 100, 300 nm
	103	select	weather radar gain	value
	104	select	weather radar angle	degrees
	105	select	ground warning status	on, off
	106	enter	data into <subsystem>	summary procedure
	107	monitor	subsystem for info	
	108	monitor	subsystem status	
	109	correct	subsystem fault	summary procedure
	110	determine	present position	summary procedure
	111	execute	cleanup after take-off	summary procedure
	112	execute	INS update	summary procedure
	113	execute	radar nav fix	summary procedure
	114	execute	TACAN nav fix	summary procedure
	115	execute	visual nav fix	summary procedure
Manage Flight Coordination	116	locate	object	rel-az, rel-el, range, hdg
	117	monitor	other a/c	rel-az, rel-el, range, hdg
	118	monitor	OW for landmarks	
	119	monitor	OW for obstacles	
	120	monitor	time-to-go	time
	121	callout	event	checklist position
	122	monitor	comm message	communication
	123	request	checklist initiation	communication
	124	request	clearance from ATC	communication
	125	request	flaps	communication
	126	request	gear	communication
	127	respond	ATC command	communication
	128	respond	checklist item	communication

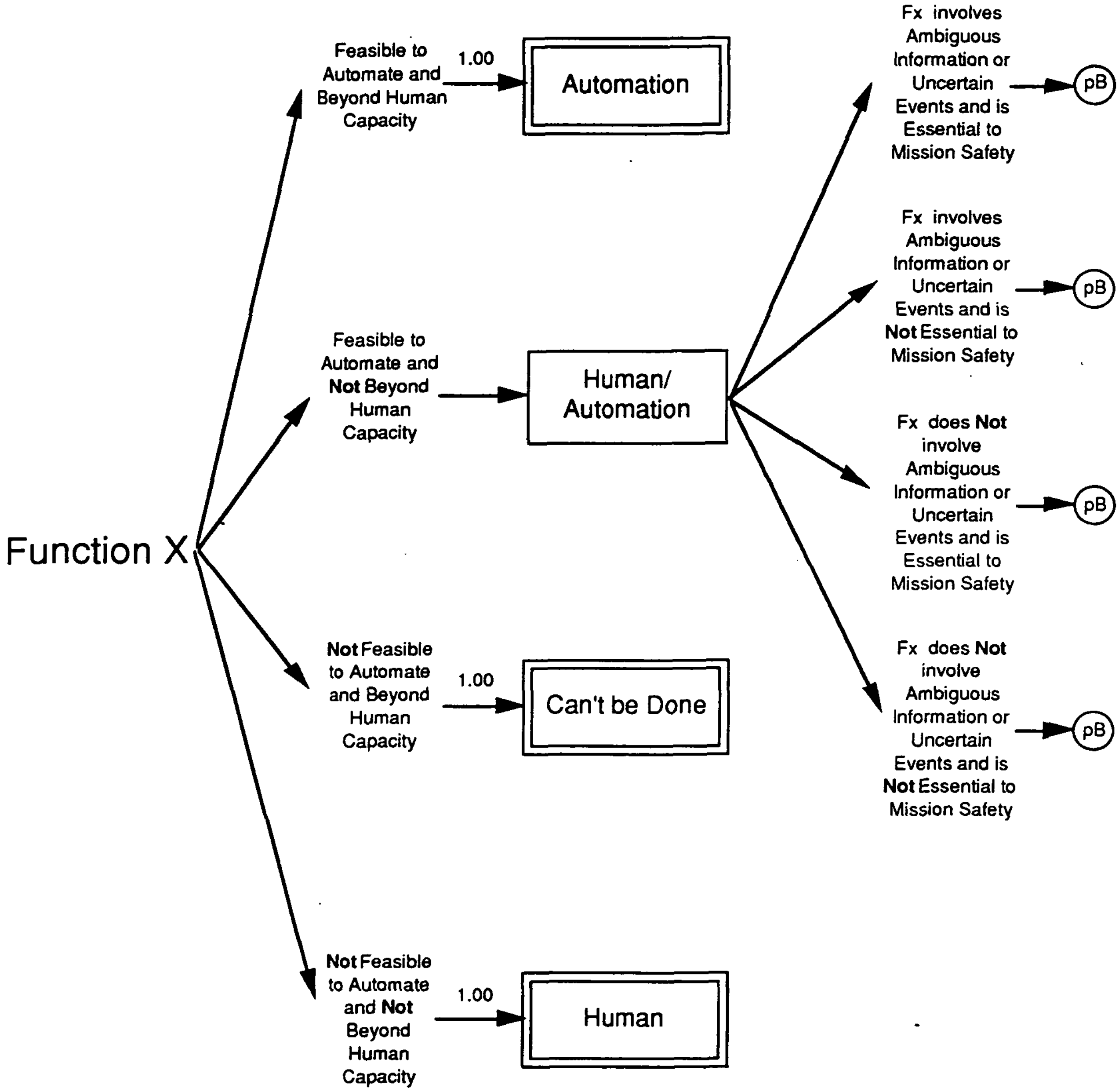
APPENDIX L

RULE SYSTEM FOR FUNCTION ALLOCATION METHODOLOGY, METHOD B

This appendix depicts, in diagrammatic form, the ordered rule system developed for the function allocation methodology in Method B. As the diagram suggests, the rules are to be interpreted from left to right, and from page to page (herein referred to as "panels"). The below key provides a guide to the symbology used on the panels. All probability assignments associated with allocation decisions are subjective estimates.

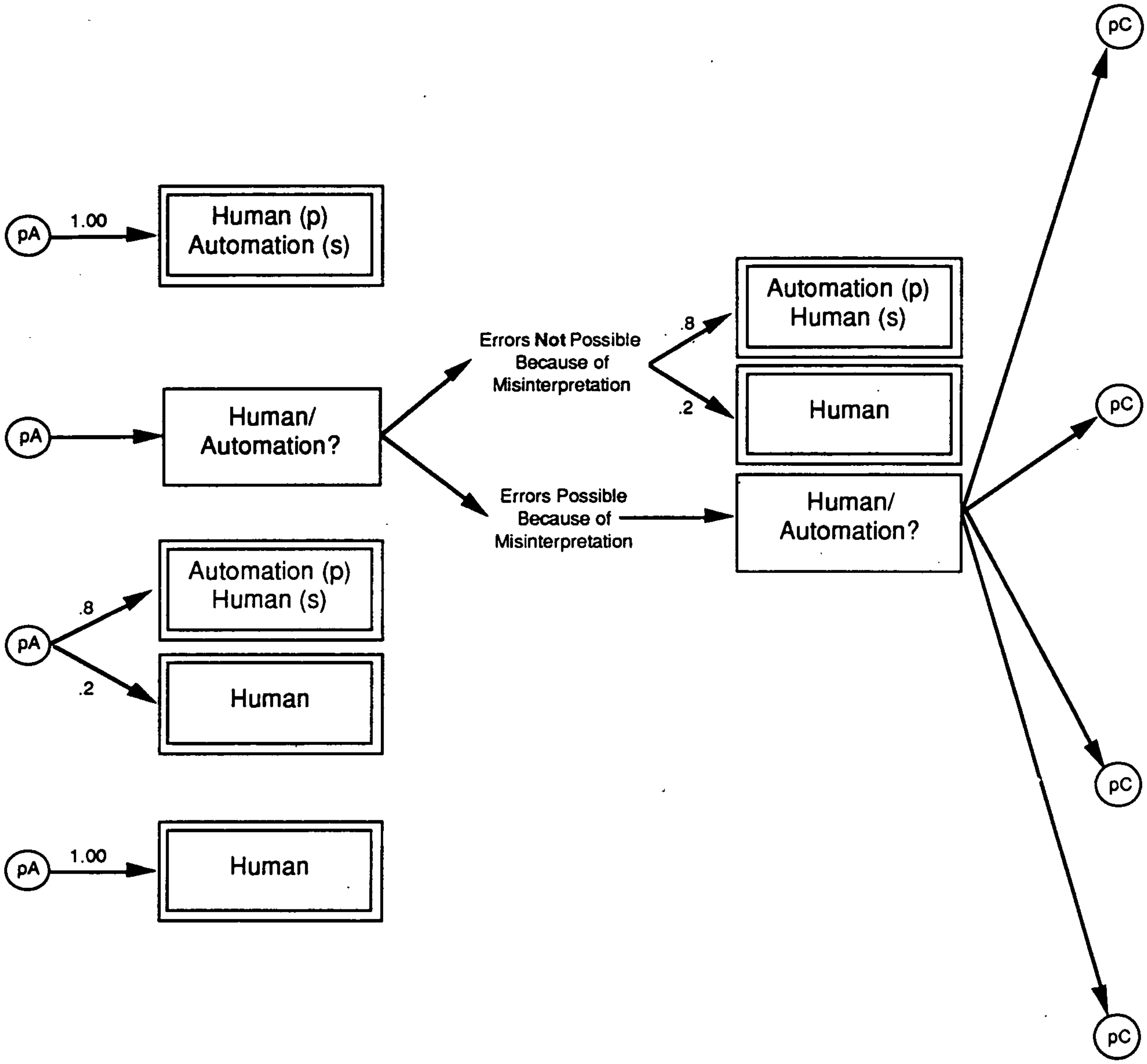
Key to panel symbology:	
Fx	= Function X
p	= primary
s	= secondary
pA-pF	= Panel A - Panel F

PANEL A



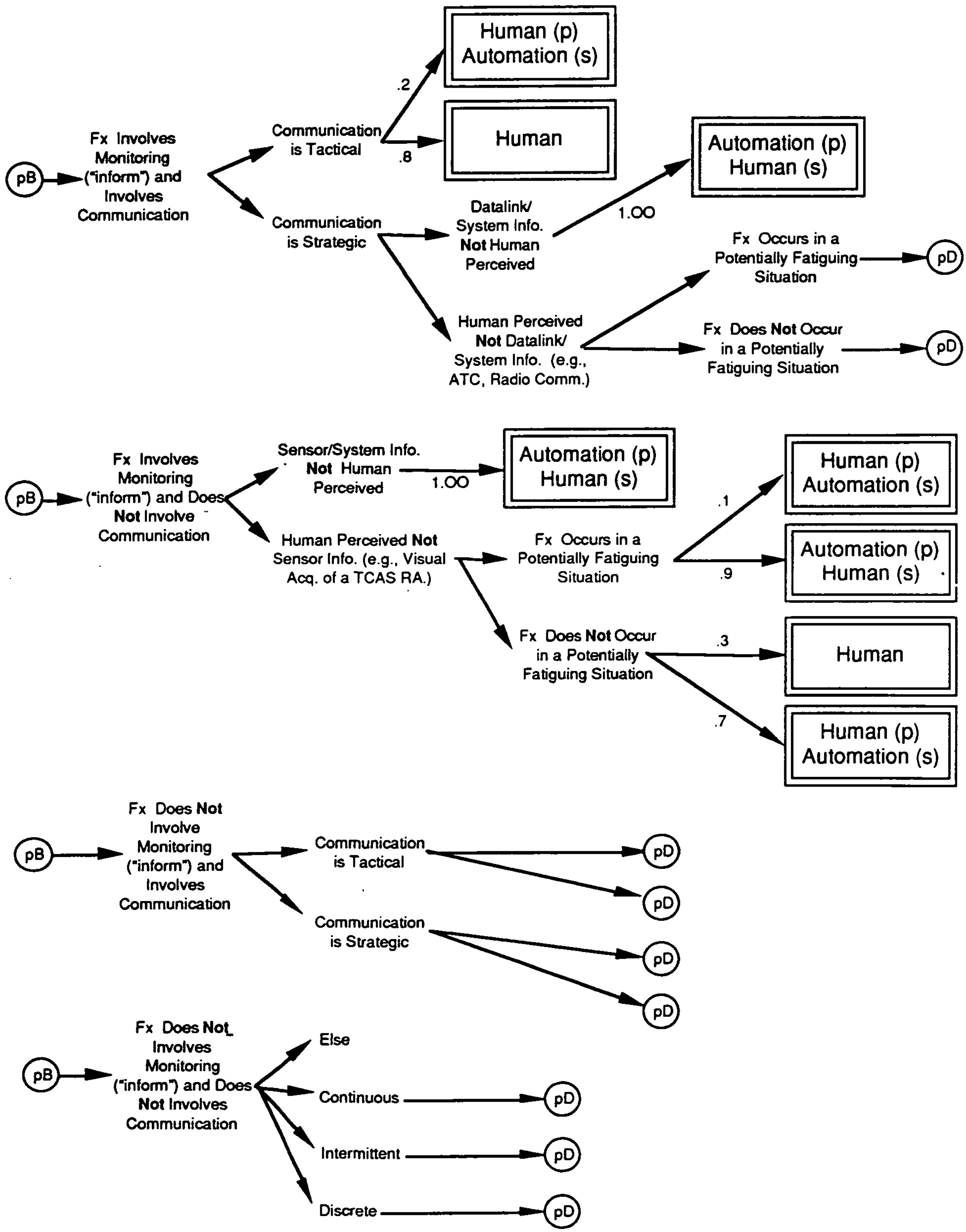
Function X
Feasible to Automate and Beyond Human Capacity
1.00
Automation
Feasible to Automate and **Not** Beyond Human Capacity
Human/ Automation
Not Feasible to Automate and Beyond Human Capacity
1.00
Can't be Done
Not Feasible to Automate and **Not** Beyond Human Capacity
1.00
Human
Fx involves Ambiguous Information or Uncertain Events and is Essential to Mission Safety
pB
Fx involves Ambiguous Information or Uncertain Events and is **Not** Essential to Mission Safety
pB
Fx does **Not** involve Ambiguous Information or Uncertain Events and is Essential to Mission Safety
pB
Fx does **Not** involve Ambiguous Information or Uncertain Events and is **Not** Essential to Mission Safety
pB

PANEL B



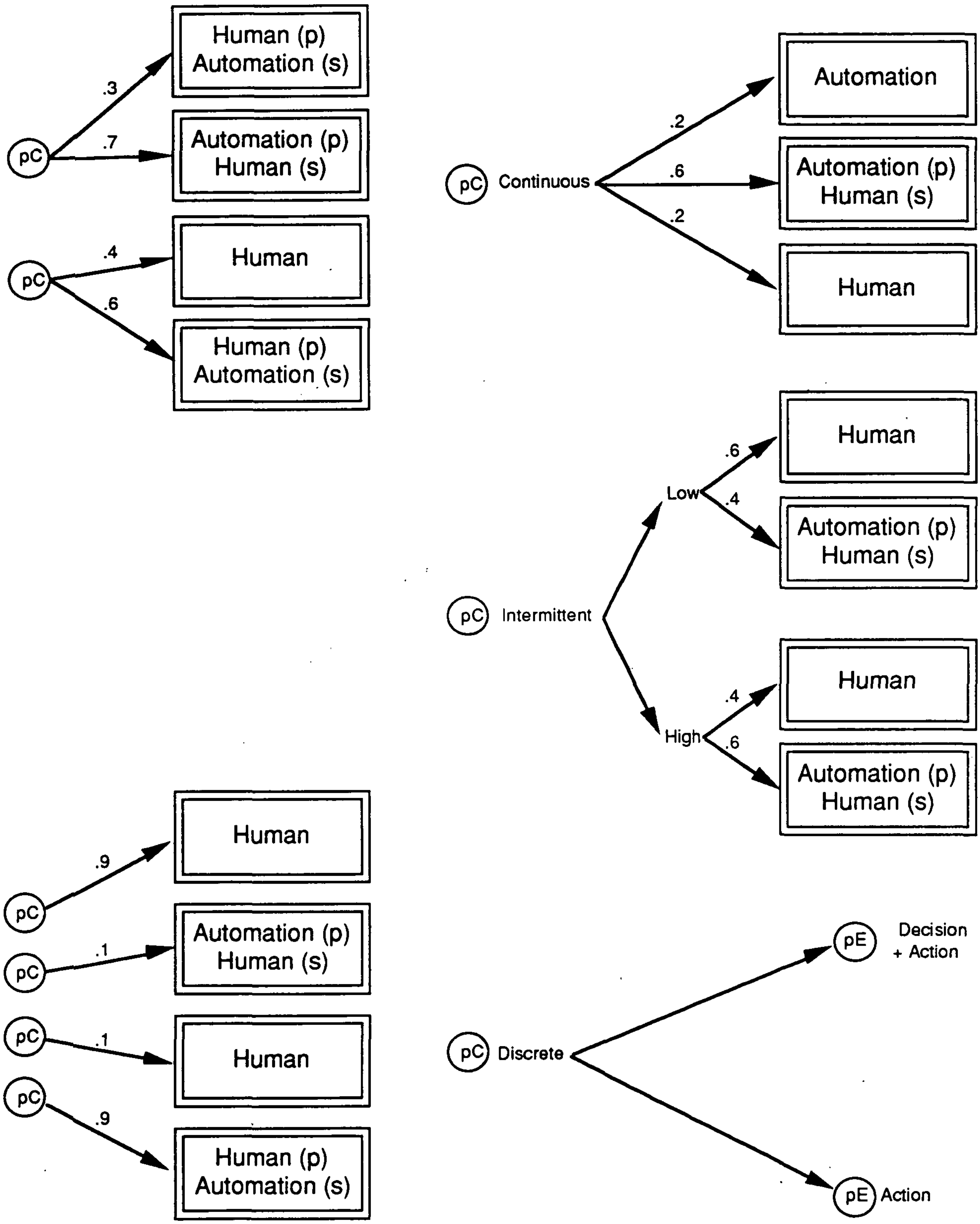
pA
1.00
Human (p)
Automation (s)
pA
Human/
Automation?
Errors Not Possible
Because of
Misinterpretation
.8
Automation (p)
Human (s)
.2
Human
Errors Possible
Because of
Misinterpretation
Human/
Automation?
pA
.8
Automation (p)
Human (s)
.2
Human
pA
1.00
Human
pC
pC
pC
pC

PANEL C



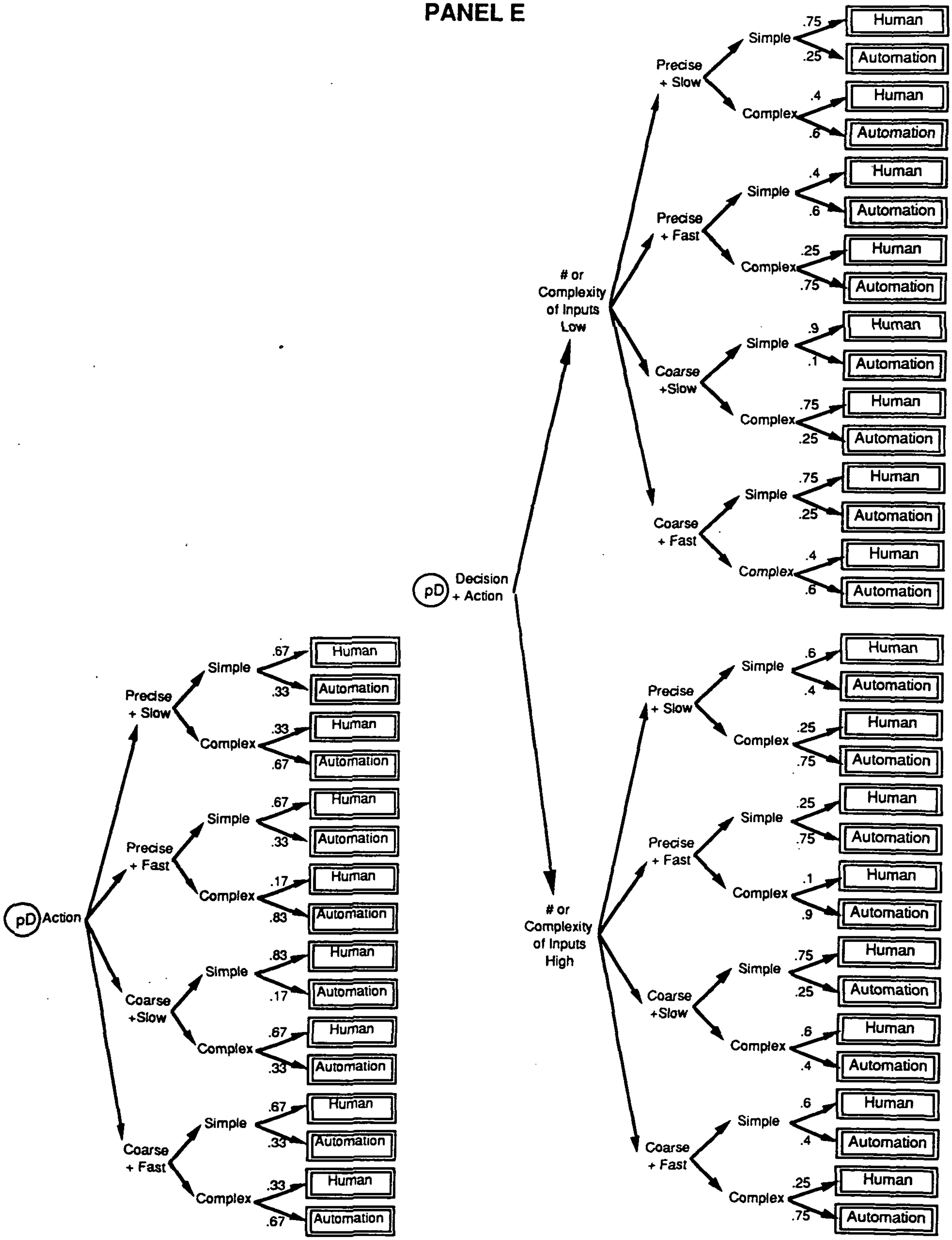
pB
Fx Involves Monitoring ("inform") and Involves Communication
Communication is Tactical
.2
Human (p) Automation (s)
.8
Human
Communication is Strategic
Datalink/ System Info. Not Human Perceived
1.00
Automation (p) Human (s)
Human Perceived Not Datalink/ System Info. (e.g., ATC, Radio Comm.)
Fx Occurs in a Potentially Fatiguing Situation
pD
Fx Does Not Occur in a Potentially Fatiguing Situation
pD
pB
Fx Involves Monitoring ("inform") and Does Not Involve Communication
Sensor/System Info. Not Human Perceived
1.00
Automation (p) Human (s)
Human Perceived Not Sensor Info. (e.g., Visual Acq. of a TCAS RA.)
Fx Occurs in a Potentially Fatiguing Situation
.1
Human (p) Automation (s)
.9
Automation (p) Human (s)
Fx Does Not Occur in a Potentially Fatiguing Situation
.3
Human
.7
Human (p) Automation (s)
pB
Fx Does Not Involve Monitoring ("inform") and Involves Communication
Communication is Tactical
pD
pD
Communication is Strategic
pD
pD
pB
Fx Does Not Involves Monitoring ("inform") and Does Not Involves Communication
Else
Continuous
pD
Intermittent
pD
Discrete
pD

PANEL D



pC
.3
Human (p)
Automation (s)
.7
Automation (p)
Human (s)
pC
.4
Human
.6
Human (p)
Automation (s)
pC Continuous
.2
Automation
.6
Automation (p)
Human (s)
.2
Human
pC Intermittent
Low
.6
Human
.4
Automation (p)
Human (s)
High
.4
Human
.6
Automation (p)
Human (s)
pC
.9
Human
pC
.1
Automation (p)
Human (s)
pC
.1
Human
pC
.9
Human (p)
Automation (s)
pC Discrete
pE Decision + Action
pE Action

PANEL E


pD Action
Precise + Slow
Simple
.67 Human
.33 Automation
Complex
.33 Human
.67 Automation
Precise + Fast
Simple
.67 Human
.33 Automation
Complex
.17 Human
.83 Automation
Coarse +Slow
Simple
.83 Human
.17 Automation
Complex
.67 Human
.33 Automation
Coarse + Fast
Simple
.67 Human
.33 Automation
Complex
.33 Human
.67 Automation
pD Decision + Action
or Complexity of Inputs Low
Precise + Slow
Simple
.75 Human
.25 Automation
Complex
.4 Human
.6 Automation
Precise + Fast
Simple
.4 Human
.6 Automation
Complex
.25 Human
.75 Automation
Coarse +Slow
Simple
.9 Human
.1 Automation
Complex
.75 Human
.25 Automation
Coarse + Fast
Simple
.75 Human
.25 Automation
Complex
.4 Human
.6 Automation
or Complexity of Inputs High
Precise + Slow
Simple
.6 Human
.4 Automation
Complex
.25 Human
.75 Automation
Precise + Fast
Simple
.25 Human
.75 Automation
Complex
.1 Human
.9 Automation
Coarse +Slow
Simple
.75 Human
.25 Automation
Complex
.6 Human
.4 Automation
Coarse + Fast
Simple
.6 Human
.4 Automation
Complex
.25 Human
.75 Automation

APPENDIX M

SAMPLE EVALUATIONS OF THE FUNCTION ALLOCATION METHODOLOGY, METHOD B

This appendix presents two sample evaluations (in Tables M-I and M-II) of the function allocation methodology for Method B: The *Liftoff* segment of the *Takeoff* phase, and the *Descent to Outer Marker* segment of the *Approach* phase. Each sample contains several data fields. First, functional descriptions from the Analysis Format database are included. The next field comprises a pilot's responses to decision criteria employed in the function allocation rule system (see Appendix L). Finally, two versions of allocation outcomes from this rule system are presented. One outcome field is generated from the rule system described in Appendix L. The other outcome field is also based on the rule system, but this time excluding two problematic decision criteria: "Does the function involve ambiguous or vague information, or occur in an uncertain context?" and "Is the function essential to the mission's completion or to safety?"

TABLE M-I — SAMPLE EVALUATION OF THE PROCESS B FUNCTION ALLOCATION METHODOLOGY USING THE LIFTOFF SEGMENT OF THE TAKEOFF PHASE

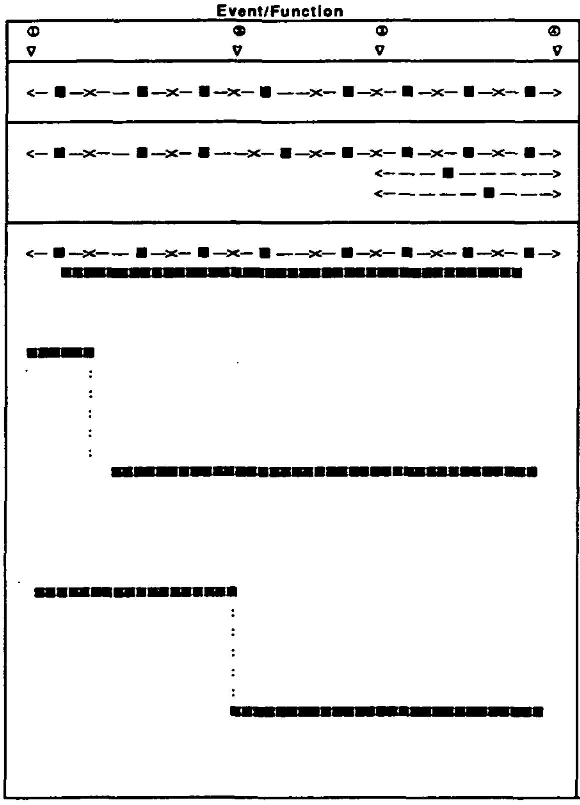
ANALYSIS FORMAT

∇	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Attain rotation speed	00:06:00
	2	Attain climb speed	
	3	Attain stable flight	
	4	Arrive at 50 FT AGL	00:06:45

1	Mission:	LAX to JFK
1.2	Period:	Departure
1.2.2	Phase:	Takeoff
1.2.2.2	Segment:	Liftoff

Event/Function



		Function	Dependency: Event Pro	Event Ret	Function Seq	Function Con
F1		Manage Flight Coordination				
	a	Monitor Partyline				
F2		Manage Aircraft Systems/Procedures				
	a	Monitor systems status				
	b	Raise landing gear	E3	E4		
	c	Disarm ground spoilers	E3	E4		
F3		Manage Aircraft Movement				
	a	Monitor Ground/Flight Path				
	b	Maintain heading				F3c-f
		1 Monitor indicated/commanded heading				
		2 Evaluate heading change requirements				
		3 Modify roll commands as required				
	c	Rotate aircraft to takeoff attitude	E1			F3bef
		1 Select nose up attitude target				
		2 Command pitch up				
		3 Monitor indicated/commanded attitude				
		4 Evaluate attitude change requirements				
		5 Modify pitch commands as required				
	d	Ascend to 50 FT AGL			F3c	F3bef
		1 Select altitude increase target				
		2 Command pitch up attitude				
		3 Monitor indicated/commanded altitude				
		4 Evaluate altitude increase progress				
		5 Modify pitch commands as required				
	e	Accelerate to climb speed (V2+10)	E1			F3bcd
		1 Select speed increase target				
		2 Command Forward Thrust Increase				
		3 Monitor Indicated/Commanded Speed				
		4 Evaluate Speed Increase Progress				
		5 Modify thrust commands as required				
	f	Maintain climb speed	E2		F3e	F3bd
		1 Monitor indicated/commanded speed				
		2 Evaluate speed change requirements				
		3 Modify thrust commands as required				

TABLE M-I — (Continued)

Performance Schedule	Performance Category	Function Feasible to Automate? no=0,yes=1	Function Beyond Human Capacity? no=0,yes=1	Function Involve Ambiguous or Uncertain Info./Events? no=0,yes=1	Function Essential to the Mission or to Safety? no=0,yes=1	Misinterp. Errors Possible? no=0,yes=1	Function Involve Monitoring? no=0,yes=1	Function involve Commun-ication? no=0,yes=1	Currently Communication is: Tactical or Strategic Tactical=0 Strategic=1
Intermit	Inform	0	0	1	0	1	1	0	1
Intermit	Inform	1	0	1	1	1	1	0	.
Discrete	Action	1	0	0	0	1	1	0	.
Discrete	Action	1	0	0	0	1	0	0	.
Intermit	Inform	1	0	1	1	1	1	0	.
Continu									
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	0	0	1	1	1	0	0	.
Intermit	Action	0	0	1	1	1	0	0	.
Continu									
Discrete	Decision	1	0	0	1	1	0	0	.
Discrete	Action	1	0	0	1	1	0	0	.
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	1	0	0	.
Continu									
Discrete	Decision	1	0	0	1	1	0	0	.
Discrete	Action	1	0	0	1	1	0	0	.
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	1	0	0	.
Continu									
Discrete	Decision	1	0	0	1	1	0	0	.
Discrete	Action	1	0	0	1	1	0	0	.
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	1	0	0	.
Continu									
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	1	0	0	.

TABLE M-I — (Continued)

Currently Monitoring is: Datalink/System Info or Human Perceived (e.g., TCAS,RA or ATC Voice) DL/Sys=0, H.Per.=1	Function in Potentially Fatiguing Situation? no=0,yes=1	Function is Not Monitoring and is Not Communication, but is: Continuous=0 Intermittent=1 Discrete=2	Intermittent Decision or Action Receiving a Rate of Inputs that is: Low: 0 High=1	Function is a Discrete Action or Decision Dependent on a Decision			
				Function Number or Complexity of Inputs Low=0 / High=1	Coarse=0 Precise=1	Slow=0 Fast=1	Simple=0 Complex=1
1	0	.	0	.	.	.	.
0	0	.	0	.	.	.	.
1	0	2	.	.	.	.	.
.	0	2	.	.	.	.	.
.	0	.	1	.	.	.	.
1	0	.	1	.	.	.	.
1	0	1	0	0	.	.	.
.	0	1	0	.	1	0	0
.	0	2	.	0	1	0	0
.	0	2	.	0	1	0	0
1	0	.	0	.	.	.	.
.	0	1	0	.	.	.	.
.	0	1	0	.	1	0	0
.	0	2	.	0	1	0	0
.	0	2	.	0	1	0	0
1	0	.	0	.	.	.	.
.	0	1	0	0	.	.	.
.	0	1	0	.	1	0	0
.	0	2	.	0	1	0	0
.	0	2	.	.	0	0	0
1	0	.	0	.	.	.	.
.	0	1	0	0	.	.	.
.	0	1	0	.	1	0	0
1	0	1	0	.	.	.	.
.	0	1	0	0	.	.	.
.	0	1	0	.	1	0	0

TABLE M-I — (Continued)

Function is a Discrete Action or Dec. Not Dependent on a Decision			ALLOCATION COMPONENTS(ALL RULES)							
Coarse=0 Precise=1	Slow=0 Fast=1	Simple=0 Complex=1	Imposs.	Human Allocation	Human Prim. Auto. Second.	Automation Allocation	Auto.Prim. Human Second.	Human/ Automation	Allocation Confidence	Allocation
.	.	.		1.00					high	Human
.	.	.			1.00				high	H(p)A(s)
0	1	0				1.00			high	Automation
0	0	0				1.00			high	Automation
.	.	.			1.00				high	H(p)A(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		1.00					high	Human
.	.	.		1.00					high	Human
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)
.	.	.		0.20			0.80		high	A(p)H(s)

TABLE M-I — (Continued)

ALLOCATION COMPONENTS(- AMB. EVENTS/SAFETY)							
Impossible	Human Allocation	Human Primary Auto. Second.	Automation Allocation	Auto.Primary Human Second.	Human/ Automation	Allocation Confidence	Allocation
	1.00					high	Human
				1.00		moderate	A(p)H(s)
	0.30	0.70				moderate	H(p)A(s)
	0.83		0.17			low	Human
				1.00		moderate	A(p)H(s)
	0.30	0.70				moderate	H(p)A(s)
	1.00					high	Human
	1.00					high	Human
	0.75		0.25			low	Human
	0.75		0.25			low	Human
	0.30	0.70				moderate	H(p)A(s)
	0.60			0.40		low	Human
	0.60			0.40		low	Human
	0.75		0.25			low	Human
	0.75		0.25			low	Human
	0.30	0.70				moderate	H(p)A(s)
	0.60			0.40		low	Human
	0.60			0.40		low	Human
	0.75		0.25			low	Human
	0.90		0.10			low	Human
	0.30	0.70				moderate	H(p)A(s)
	0.60			0.40		low	Human
	0.60			0.40		low	Human
	0.30	0.70				moderate	H(p)A(s)
	0.60			0.40		low	Human
	0.60			0.40		low	Human

TABLE M-II — SAMPLE EVALUATION OF THE PROCESS B FUNCTION ALLOCATION METHODOLOGY USING THE DESCENT TO OUTER MAKER SEGMENT

ANALYSIS FORMAT

Symbol	Meaning
▽	Event
< >	Time Window
■	Time Duration

		Event	Time
E	1	Cross intermed aprch fix	04:55:12
	2	On course	
	3	Arrive at 1900 FT MSL	
	4	Cross final aprch fix	
	5	On course/localizer	
	6	Intercept glide slope	
	7	Cross outer marker	04:59:06

1	Mission:	LAX to JFK
1	Period:	Arrival
1.4	Phase:	Approach
1.4	Segment:	Descent to outer marker

Event/Function: events 1 2 3 4 5 6 7 (▽)

	Function	Dependency: Event Pro	Event Ret	Function Seq	Function Con
F1	Manage Flight Coordination				
a	Monitor Partyline				
F2	Manage Aircraft Systems/Procedures				
a	Monitor systems status				
b	Lower landing gear	E5			
c	Extend flaps to 35 degrees				
d	Extend flaps to 50 degrees			F2c	
e	Verify ground maneuv brake sys opertn				
f	Arm spoilers for landing				
g	Access before landing checklist				
h	Verify landing gear lowered			F2g	
i	Verify auto braking system activated			F2g	
j	Verify spoilers armed			F2g	
k	verify flaps/slats extended for landing			F2g	
l	Verify altimeters set for local pressure			F2g	
m	Stow before landing checklist		E7		
F3	Manage Aircraft Movement				
a	Monitor Ground/Flight Path				
b	Maintain 155 kts				F3c-h
	1 Monitor indicated/commanded speed				
	2 Evaluate speed change requirements				
	3 Modify thrust commands as required				
c	Continue descent to 1900 FT MSL				F3be-h
	1 Monitor indicated/commanded altitude				
	2 Evaluate altitude decrease progress				
	3 Modify pitch commands as required				
d	Maintain altitude at 1900 FT MSL	E5		F3c	
	1 Monitor indicated/commanded altitude				
	2 Evaluate altitude change requirements				
	3 Modify pitch commands as required				
e	Turn to new heading (005 deg)	E1			F3bc
	1 Select roll rates				
	2 Monitor for roll in cue				
	3 Command left roll in				
	4 Monitor indicated/commanded roll rate				
	8 Command right roll out				
	9 Evaluate recovery progress				
	10 Modify roll rate as required				
f	Maintain heading (005 deg)	E2		F3e	F3bcd
	1 Monitor indicated/commanded heading				
	2 Evaluate heading change requirements				
	3 Modify roll commands as required				
g	Turn to new heading (313 deg)	E3		F3f	F3bd
	1 Select roll rates				
	2 Monitor for roll in cue				
	3 Command left roll in				
	4 Monitor indicated/commanded roll rate				
	5 Evaluate turn progress				
	6 Modify roll rate as required				
	7 Monitor for roll out cue				
	8 Command right roll out				
	9 Evaluate recovery progress				
	10 Modify roll rate as required				
h	Maintain heading (aprch runway)	E4		F3g	F3bd
	1 Monitor indicated/commanded heading				
	2 Evaluate heading change requirements				
	3 Modify roll commands as required				
F4	Manage Flight Plan				
a	Monitor flight progress				
F5	Manage Contingencies				
a	Prepare for missed approach				
	1 Select missed aprch recovery altitude			F2g	

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TABLE M-II — (Continued)

Performance Schedule	Performance Category	Function Feasible to Automate? no=0,yes=1	Function Beyond Human Capacity? no=0,yes=1	Function Involve Ambiguous or Uncertain Info./Events? no=0,yes=1	Function Essential to the Mission or to Safety? no=0,yes=1	Misinterp. Errors Possible? no=0,yes=1	Function involve Monitoring? no=0,yes=1	Function involve Communication? no=0,yes=1	Currently Communication is: Tactical or Strategic Tactical=0 Strategic=1
Intermit	Inform	0	0	0	0	1	1	1	0
Intermit	Inform	1	0	1	1	1	1	0	.
Descrete	Action	1	0	0	1	0	0	0	.
Descrete	Action	1	0	0	1	0	0	0	.
Descrete	Action	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	1	1	0	0	0	.
Descrete	Action	1	0	0	1	0	0	0	.
Descrete	Action	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	0	1	0	0	0	.
Descrete	Decision	1	0	0	1	1	0	0	.
Descrete	Action	1	0	0	0	0	0	0	.
Intermit	Inform	1	0	1	1	0	1	0	.
Continu									
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Intermit	Inform	1	0	0	1	1	1	0	.
Intermit	Decision	1	0	0	1	1	0	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Discrete	Decision	1	0	0	1	1	0	0	.
Intermit	Inform	1	0	0	1	0	1	0	.
Discrete	Action	1	0	0	1	0	0	0	.
Intermit	Inform	1	0	0	1	0	1	0	.
Discrete	Action	1	0	0	1	0	0	0	.
Intermit	Decision	1	0	0	1	0	1	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Intermit	Inform	1	0	0	1	0	1	0	.
Intermit	Decision	1	0	0	1	0	0	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Discrete	Decision	1	0	0	1	1	0	0	.
Intermit	Inform	1	0	0	1	0	1	0	.
Discrete	Action	1	0	0	1	0	0	0	.
Intermit	Inform	1	0	0	1	0	1	0	.
Intermit	Decision	1	0	0	1	0	1	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Intermit	Inform	1	0	0	1	0	1	0	.
Discrete	Action	1	0	0	1	0	0	0	.
Intermit	Decision	1	0	0	1	0	1	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Continu									
Intermit	Inform	1	0	0	1	0	1	0	.
Intermit	Decision	1	0	0	1	0	0	0	.
Intermit	Action	1	0	0	1	0	0	0	.
Intermit	Inform	1	0	1	1	1	1	0	.
Discrete	Decision	1	0	0	1	1	0	0	

TABLE M-II — (Continued)

Currently Monitoring is: Datalink/System Info or Human Perceived (e.g., TCAS,RA or ATC Voice) DL/Sys=0, H.Per.=1	Function in Potentially Fatiguing Situation? no=0,yes=1	Function is Not Monitoring and is Not Communication, but is: Continuous=0 Intermittent=1 Discrete=2	Intermittent Decision or Action Receiving a Rate of Inputs that is: Low: 0 High=1	Function is a Discrete Action or Decision Dependent on a Decision			
				Function Number or Complexity of Inputs Low=0 / High=1	Coarse=0 Precise=1	Slow=0 Fast=1	Simple=0 Complex=1
1	0		0	0			
1	0			0			
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	0	0	0
.	0	2	0	0	1	0	0
.	0	2	0	0	0	0	0
1	0			1			
1	0			0	1	0	0
.	0	1	0	1	1	0	0
.	0	2	0	0			
1	0			0			
.	0	1	0	1	1	0	1
.	0	2	0	0			
1	0			0			
.	0	1	0	1	1	0	1
.	0	2	0	0			
.	0	2	0	1	1	1	1
1	0			0			
.	0	2	0	0	0	0	0
1	0			0			
.	0	2	0	0			
1	0	0	1	1	1	0	1
.	0	2	0	0			
1	0			0			
.	0	1		0	0	0	1
.	0	2	0	0			
.	0	2	0	1	1	1	1
1	0			0			
.	0	2	0	0			
1	0			0			
1	0		1	1	1	0	1
.	0	1	1	1			
1	0			0			
.	0			0			
1	0	0	1	1	1	0	1
.	0	1	1	1	1	1	1
1	0			0			
.	0	1	0	0	0	0	1
.	0	1	0	0	0	0	0
1	1		1	1			
	0	2		0	1	1	0

TABLE M-II — (Continued)

Function is a Discrete Action or Decision Not Dependent on a Decision			ALLOCATION COMPONENTS(ALL RULES)					
Coarse=0 Precise=1	Slow=0 Fast=1	Simple=0 Complex=1	Impossible	Human Allocation	Human Primary Auto. Second.	Automation Allocation	Auto.Primary Human Second.	Human/ Automation
				1.00				
					1.00			
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
					1.00			
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
					1.00			
					1.00			
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
1	0	1		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
1	0	1		0.20			0.80	
				0.20			0.80	
0	0	0		0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
				0.20			0.80	
					1.00			
				0.20			0.80	

TABLE M-II — (Continued)

		ALLOCATION COMPONENTS(- AMB. EVENTS & SAFETY)							
Allocation Confidence	**Allocation**	**Impossible**	**Human Allocation**	**Human Primary Auto. Second.**	**Automation Allocation**	**Auto.Primary Human Second.**	**Human/ Automation**	**Allocation Confidence**	**Allocation**
high	Human		1.00					high	Human
high	H(p)A(s)		0.30	0.70				moderate	H(p)A(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)		0.75		0.25			low	Human
high	Automate		0.20			0.80		moderate	A(p)H(s)
high	H(p)A(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.30	0.70				moderate	H(p)A(s)
high	A(p)H(s)		0.60		0.40			low	Human
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.30	0.70				moderate	H(p)A(s)
high	A(p)H(s)		0.60			0.40		low	Human
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.30	0.70				moderate	H(p)A(s)
high	A(p)H(s)		0.60			0.40		low	Human
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.10		0.90			low	Automate
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.10		0.90				Automate
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	A(p)H(s)		0.20			0.80		high	A(p)H(s)
high	H(p)A(s)			0.10		0.90		moderate	A(p)H(s)
low	A(p)H(s)		0.40		0.60			low	Automate

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16. Abstract

This study explores the applicability of functional analysis methods to support the cockpit design process. Specifically, the study investigates alternative techniques for ensuring an effective division of responsibility between the flight crew & automation.This project performed a functional decomposition of the commercial flight domain to provide the information necessary to support allocation decisions and demonstrated methodology for allocating functions to flight crew or to automation. The function analysis employed "Bottom-Up" and "Top-Down" analyses and demonstrated the comparability of identified functions, using the "Lift-Off" segment of the "Take-Off" phase as a test case. The normal flight mission and selected contingencies were addressed. Two alternative methods for using the functional description in the allocation of functions between man and machine were investigated. The two methods were compared in order to ascertain their relative strengths and weaknesses. Finally, conclusions were drawn regarding the practical utility of function analysis methods.

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